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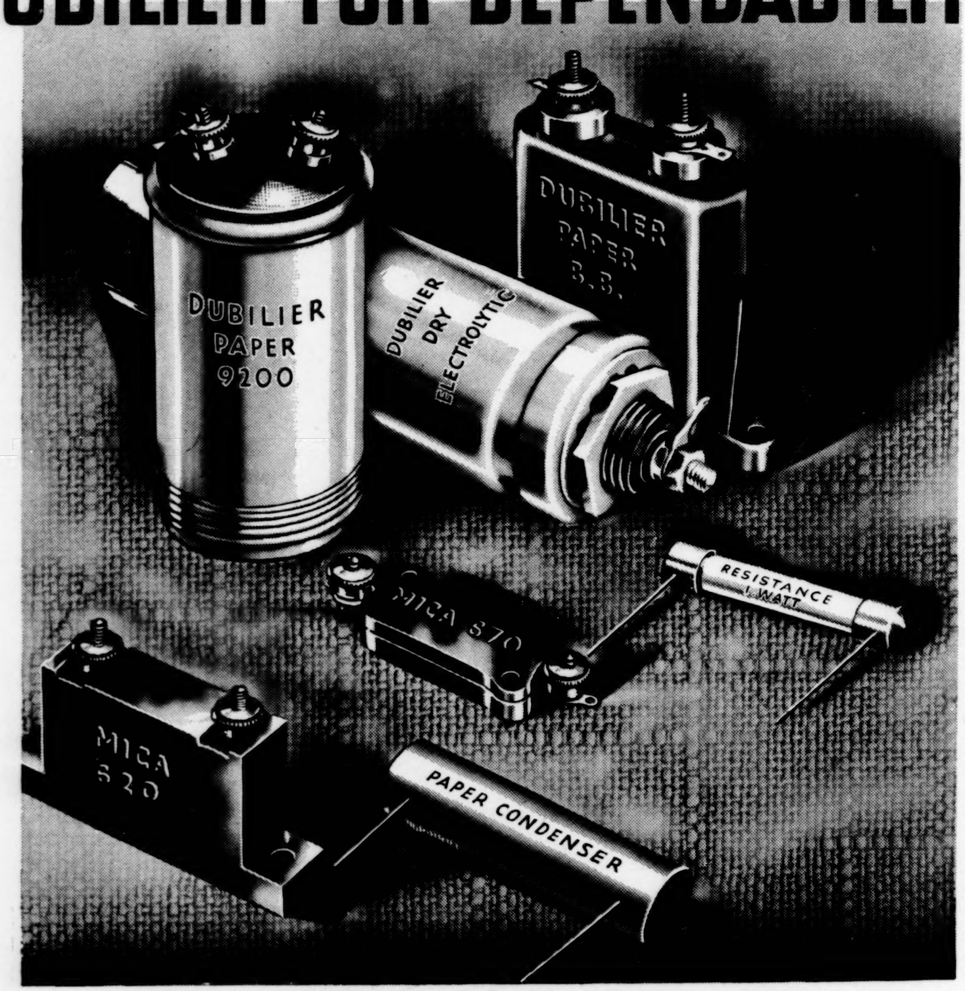
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VOL. XI. SEPTEMBER, 1934 No. 132

Editorial

Second Channel and Harmonic Reception in Superheterodynes

IN an article in *Die Telefunken-Röhre*—a magazine devoted to valves, the first number of which has just been issued by the Telefunken Company—reference is made to the problem of the elimination of harmonic production in superhets, and the suggestion is made that trouble that is sometimes ascribed to the production of harmonics is often due to back-coupling from the output of the intermediate stages, especially when the high frequency is an exact multiple of the intermediate frequency.

As we possess a superhet which is very rich in whistles and chirps and given to the picking up of stations in most unexpected points on the dial, we thought that it would be interesting to examine these abnormal receptions systematically and determine the cause of each one. The set is a commercial one of 1931 with no h.f. amplifying valve, but with a separate oscillator which is coupled to the first detector by a resistance which is common to the cathode leads of the two valves. Between the aerial and the grid of the detector valve is a capacity-coupled two-circuit tuner. The intermediate filters are tuned to a frequency of 115 kilocycles per sec. and the oscillator frequency is above that of the h.f. filter by this amount.

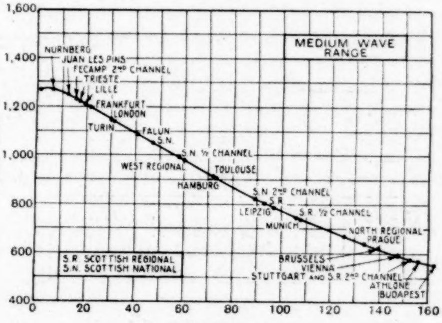

Fig. 1.

The calibration curves on the medium and long-wave ranges are reproduced in Figs. 1 and 2. In the former there are only five abnormal receptions three of which are due to second channel, but in the long-wave range there are many more, only one of which is due to second channel, the remainder being due to the received station differing in frequency by 115 kc/sec. from a harmonic of the oscillator. The table shows exactly how each abnormal reception is caused. Only those cases are plotted which were loud enough to be identified with certainty. There are two points, however, which should be emphasised; firstly, the results obtained in such a test depend on the locality; the results here given were obtained in Glasgow, which is 23 miles from the Scottish transmitter; secondly, it is not suggested that the receiver could not be modified or adjusted so as to reduce some of these abnormal receptions below audibility.

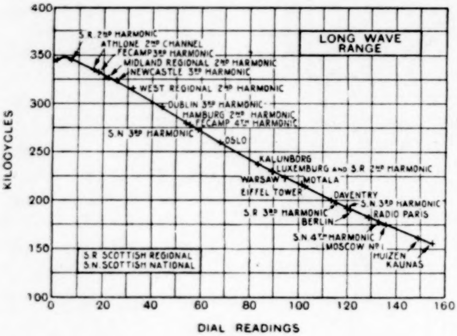

Fig. 2.

There is another cause of abnormal reception which we have not included in the table, and which might be called half-channel. In this set, for example, the Scottish National programme on 1,050 kc can be received quite loudly at a reading corresponding to 992.5 kc; this appears somewhat mysterious until one notices that the oscillator frequency of 992.5 + 115 = 1,107.5 kc differs from the received frequency by 57.5, which is exactly half of 115. The first detector will not produce a pure 57.5 kc current but probably one with a pronounced second harmonic which will pass through the intermediate filter and cause the reception of the Scottish National programme. Scottish Regional on 804 kc is similarly received at a reading corresponding to 746.5 kc. These examples emphasise the importance of working the first detector in such a manner that the intermediate frequency is as free from harmonics as possible.

When quickly turning the tuning dial of a superhet one often notices a number of sounds which, if not too loud, may best be described as chirps; if they are very loud this name hardly does them justice. If the dial is slowly rotated a very high note becomes audible, the pitch of which falls to zero and then, on further turning the dial, rises again until it exceeds the limit of audibility. To explain the cause of this phenomenon we shall consider one or two actual

Table Showing Abnormal Receptions.

Medium Wave Range.

Dial Reading.	Station Received.	Frequency in kc/s of			Explanation Intermediate Frequency = 115 kc/s.	
		Aerial Circuits.	Oscillator.	Station.		
15.5	Fécamp	1,226	1,341	1,456	1,456 − 1,341 = 115	2nd channel
89	Scottish National . .	820	935	1,050	1,050 − 935 = 115	2nd ,,
153	Scottish Regional . .	574	689	804	804 − 689 = 115	2nd ,,
	Long Wave Range.					
7.5	Scottish Regional . .	345	460	804	(2 × 460) − 804 = 116	2nd harmonic
16	Athlone	335	450	565	565 − 450 = 115	2nd channel
18	Fécamp	332	447	1,456	1,456 − (3 × 447) = 115	3rd harmonic
22	Midland Regional . .	326	441	767	(2 × 441) − 767 = 115	2nd ,,
25.5	Newcastle	323	438	1,429	(3 × 438) − 1,429 = 115	3rd ,,
44	Dublin	296	411	1,348	1,348 − (3 × 411) = 115	3rd ,,
54	Hamburg	279.5	394.5	904	904 − (2 × 394.5) = 115	2nd ,,
55.5	Fécamp	278	393	1,456	(4 × 393) − 1,456 = 116	4th ,,
59	Scottish National . .	273	388	1,050	(3 × 388) − 1,050 = 114	3rd ,,
89.5	Scottish Regional . .	230	345	804	804 − (2 × 345) = 114	2nd ,,
115.5	Scottish National . .	197	312	1,050	1,050 − (3 × 312) = 114	3rd ,,
120	Scottish Regional . .	191	306	804	(3 × 306) − 804 = 114	3rd ,,
133	Scottish National . .	176	291	1,050	(4 × 291) − 1,050 = 114	4th ,,

cases. At 115.5 on the long-wave range carrier waves are being received from Daventry at 200 kc and from Scottish National at 1,050 kc, and although the set is tuned approximately to the former, the latter station is about twice as powerful and only 23 miles away. When the dial reading is 117 the oscillator has a fundamental frequency of 310 kc and a third harmonic of 930 kc. Daventry's carrier will beat with the former to produce an intermediate frequency of 310 — 200 = 110 kc, whilst the Scottish National carrier will beat with the latter to produce an intermediate frequency of 1,050 — 930 = 120 kc. Both of these intermediate frequencies will pass through the 115 kc filter to produce at the second detector a note of 120 — 110 = 10 kc, *i.e.*, a high piping note. What happens as the dial is turned is best shown in the following manner.

Dial Reading.	Oscillator kc.		Difference kc.
117	310	310—200 = 110 1,050—(3 × 310) = 120	10
116	312	312—200 = 112 1,050—(3 × 312) = 114	2
115.5	312.5	312.5—200 = 112.5 1,050—(3 × 312.5) = 112.5	0
115	313	313—200 = 113 1,050—(3 × 313) = 111	2

As the dial reading is reduced from 117 to 115.5 the pitch of the note changes from a high piping whistle to a bass growl, and by careful adjustment at 115.5 it can be made quite inaudible, although if very strong it is almost impossible to eliminate a fluttering effect; on further reducing the dial reading the pitch rushes up until it becomes inaudibly high.

As another example we may mention Moscow No. 1, working at 174 kc, which when accurately tuned has a dial reading of 136, but is accompanied by a faint whistle which can be reduced to zero pitch by detuning to 136.5. This is probably due to West Regional working at 977 kc and arises in the following manner. When tuned to Moscow at 174 kc, the oscillator frequency is 174+115=289 kc, and it will produce a third harmonic of 867 kc which differs from West Regional by 110 kc. The two intermediate frequencies of 115 and 110 will set up a 5 kc whistle, but on slightly increasing the dial reading and thus decreasing the oscillator frequency from 289 to 287.75 the two intermediate frequencies become the same, viz., 113.75, and the difference tone vanishes. There is another possible explanation, although the station is probably too far away to cause an audible chirp, and that is the other Moscow transmitter, Moscow No. 3, which has a frequency of 401 kc and therefore an apparent second channel frequency of 401 — 230 = 171 kc which differs by only 3 kc from Moscow No. 1. This would also be reduced to zero frequency by a slight increase in the dial reading. These examples serve to illustrate the large number of possibilities of producing chirps if the oscillator has strongly pronounced harmonics and if the high-frequency stage is not sufficiently selective.

Although the harmonic content of the oscillator current in this set could doubtless be reduced by adjustment of the grid bias and anode voltages, it should be noted that the part of the anode circuit utilised for the heterodyne mixing with the received wave in this and in many other sets is the least satisfactory from the point of view of freedom from harmonics. The oscillatory or flywheel circuit will have a much smaller percentage of harmonics than the anode or cathode lead, the current in which is known to have a relatively bad wave-form. In the set with which these tests were made the cathode current is passed through a resistance, the drop across which is injected into the cathode circuit of the first detector; no use is made of the purifying effect of the resonant circuit of the oscillator in building up a large current of the resonant frequency and thus reducing the relative importance of the harmonics.

With regard to the suggestion referred to in the opening paragraph, we can only say that, in this set, every case of abnormal reception could be explained without reference to any back-coupling between the second and first detector.

G. W. O. H.

The Grid-Anode Capacity of Valves*

Its Effect on the Associated Tuned Circuits

By M. O'Connor Horgan, M.Sc.

(Research Laboratories of the General Electric Company, Wembley, England)

ABSTRACT.—The paper includes expressions for the variation of the damping and capacity reflected onto the grid circuit from the anode circuit for all positions of the anode tuning. Expressions and curves are derived such that these effects can be at once determined when certain of the circuit constants of the amplifier are known. From further curves the magnitudes of several other effects can be found for any amplifier stage, whilst the change of the overall response curve of the amplifier due to the grid-anode capacity is evaluated.

I. Introduction

PRIOR to the introduction of the Screen-Grid valve, the question of the grid-anode capacity of a valve, used as a high-frequency amplifier, was of importance due to the instability that it caused when the overall amplification exceeded a certain point. When steps had been taken partly to neutralise the feed-back effect, the maximum amplification was still limited by the question of stability rather than the maximum amplifying power of the valve in association with good tuned circuits.

With the introduction of the screen-grid valve with its greatly reduced grid-anode capacity, instability, when it occurred was invariably produced by stray external couplings, and the question of inter-electrode capacity, becoming of minor importance, rather faded to the background.

Since then, further research has produced more efficient valves, having greater and greater mutual conductances, and more efficient tuning coils, so that, in spite of the huge reduction in grid-anode capacities and the improvement in the external screening, the point is again being reached when the internal coupling between the anode and grid circuits is making its presence felt. In some cases already, it is again the limiting factor in the amplification attainable from an amplifier stage.

There are three papers on this subject that are worthy of note, namely:

(*a*) Beatty, "The Stability of the Tuned Grid-Tuned Plate H.F. Amplifier," *E.W. & W.E.*, Jan. 1928, Vol. 5, p. 3.

(*b*) Beatty, "Stability of Valve Amplifiers," *Proc. Phys. Soc.*, Vol. 40, 1928, p. 261.

(*c*) Butterworth, *E.W. & W.E.*, Vol. 6, No. 69, 1929, p. 293.

These deal chiefly with the maximum amplification that is attainable, and the conditions for stability. But other results follow from an appreciable anode-grid capacity, notably with regard to the tuning of the anode and grid circuits. At the present day, when the high selectivity of a set and the accurate adjustment of its H.F. filters are so dependent on the critical tuning of its resonant circuits, the variations introduced by the grid-anode capacity may be serious.

In the following paper expressions are derived for both the stability and the variations in the tuning conditions of the associated anode and grid circuits, together with their effect on the consequent response of the amplifier. As far as possible, these are expressed in such a form as to be easily applied to any amplifier stage whose operating constants are known or can be easily measured; and from the expressions obtained, curves are drawn so that the actual effect for any circuit conditions can be read off. Practical confirmation of all the expressions derived has been obtained to a high degree of accuracy as will be mentioned later in the text.

The circuit considered is that of a single stage high-frequency amplifier having resonant tuned circuits in both its grid and anode circuits as shown in Fig. 1. For the practical measurements the grid and anode circuits are elaborately screened, and provision is made for injecting an H.F. voltage into the

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* MS. accepted by the Editor, May, 1934.

grid circuit by means of a small resistance R_4 of less than 1 ohm. The output across the anode tuned circuit can be measured by a valve-voltmeter.

The tuning of the anode circuit is carried out firstly by a fixed condenser C_5 of suitable

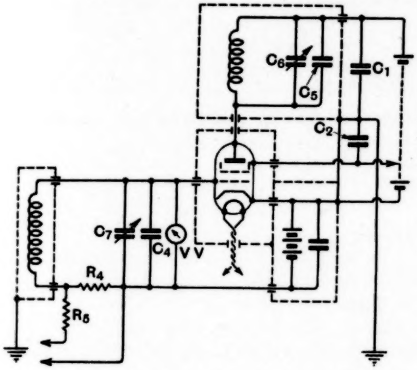

Fig. 1.—*The H.F. amplifier stage used in the practical tests. The condenser C_6 is a standard 10–75 μμF condenser, whilst C_7 is a specially constructed standard of small capacity differences and is graduated to 0.01 μμF. The comprehensive screening eliminates all feed-back between the anode and grid circuits except through the valve itself.*

size, and a parallel standard condenser having a range of 9 — 75 μμF. On the grid side besides the fixed condenser C_4 there is a parallel condenser C_7 which has a scale of 15 μμF, divided into 1/100ths of a micro-microfarad.† With such a condenser, change of capacity of the order of 0.005 μμF could be measured. In the present case, however, a limit of 0.01 μμF was set by the sensitivity of the resonance indicator.

2. The Fundamental Equations

The amplifier stage has an equivalent circuit which may be drawn as shown in Fig. 2. Here an injected voltage e is amplified by the grid tuned circuit, causing a voltage e_1 on the grid of the valve. Further amplification in the valve is equivalent to having a second source of voltage μe_1 in the valve, in series with the valve conductance σ_v, across the anode tuned circuit.

The fundamental formulae connecting e, e_1, and e_2, were derived by Beatty* for such a circuit by considering a series of "circulating currents" in the various loops. Their derivation is straightforward and need not be repeated here. They are †:

$$e_1\sigma_1(1 + jt_1) - e_2 j\omega C_0 = -\frac{je}{\omega L_1} \quad \cdots \quad (1)$$

$$e_2\sigma_2(1 + jt_2) + e_1 g = 0 \quad \cdots \quad \cdots \quad (2)$$

By suitably eliminating one or other of the three voltages we obtain the expression for the interdependence of the other two.

3. The Variation of the H.F. Voltage on the Grid as the Anode is Tuned

Owing to the mutual coupling of the grid and anode circuits through the grid-anode capacity, changes of tuning in the anode circuit produce a variation in the magnification of the grid tuned circuit.

By eliminating e_2 from equations (1) and (2) we get the connection between the magnification of the tuned circuit, and the anode tuning expressed as a phase tangent t_2.

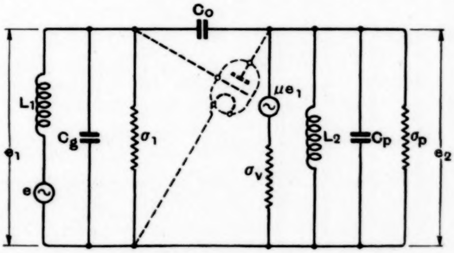

Fig. 2.—*The amplifier stage, shown in Fig. 1, may be represented completely by this equivalent circuit. The voltages e_1, e_2, etc., resulting from a small voltage e introduced into the grid circuit, are indicated.*

$$\frac{e_1}{e} = jm_1F(1 + jt_2) \quad \cdots \quad \cdots \quad \cdots \quad (3)$$

where

$$F = 1/(1 + jt_1)(1 + jt_2) + jH \text{ and } H = \frac{g\omega C_0}{\sigma_1\sigma_2}$$

This may be written

$$\frac{e_1}{e} = jm_1 \frac{1}{\left\{1 + \frac{Ht_2}{1 + t_2^2}\right\} + j\left(\frac{H}{1 + t_2^2} + t_1\right)} \quad \cdots \quad (4)$$

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† "A Standard of Small Capacity Differences," Bartlett, *Journal of Scientific Instruments*, Vol. 8, 1931, p. 260.

* Beatty, *E.W. & W.E.*, Jan., 1928, Vol. 5, p. 3.

† For list of symbols see Appendix.

It will be seen that the magnification varies with both t_1 and t_2, *i.e.*, with both the grid and anode tuning. As the grid tuning is varied, the "in-phase" component in the denominator of the above expression (4) does not vary, being independent of t_1; and we may thus say at once that the magnification of the tuned circuit will be a maximum when

$$t_1 = -\frac{H}{1 + t_2^2} \quad \cdots \quad \cdots \quad (5)$$

where $H = \frac{g\omega C_0}{\sigma_1\sigma_2}$ is a constant for a given circuit with constant supply voltages to the valve.

Thus for any setting of t_2, we may adjust the value of t_1 to give maximum amplification. Under these conditions we may write:

$$\frac{e_1}{e} = jm_1 \frac{1}{1 + \dfrac{Ht_2}{1 + t_2^2}} \quad \cdots \quad \cdots \quad (6)$$

$= jm_1K_1$ where K_1 is a function of t_2 only for constant values of H.

Now $H = \frac{g\omega C_0}{\sigma_1\sigma_2}$ where C_0 is the anode-grid capacity and σ_1 and σ_2 the conductances of grid and anode tuned circuits respectively. It will thus be constant for a given stage, so long as g, the valve mutual conductance, and the frequency ω of the injected voltage are constants. With constant applied voltages and a small signal this will be true, so that under these conditions H may be assumed to have a steady value, and may be regarded as a stage constant in a similar way that g, the mutual conductance, is regarded as a valve constant. It will be used in this paper almost as a "coupling factor" for the circuit, and as will be seen, leads directly to such data as the extra gain due to reaction.

Continuing our examination of equation (6), it will be observed that if the anode circuit is at resonance, $t_2 = 0$, and the magnification is that of a tuned circuit, m_1. If the anode circuit is inductive, t_2 is negative and the magnification is greater than that for a plain tuned circuit. Similarly, if the anode circuit is capacitive, the value of t_2 is positive and the circuit is damped, giving a magnification below normal. Further, the variable factor $\frac{Ht_2}{1 + t_2^2}$ in equation (6) has a maximum value when $t_2 = 1$, and a minimum value when $t_2 = -1$. Thus the greatest magnification occurs when $t_2 = -1$, and is equal to

$$\frac{e_1}{e} = jm_1 \frac{1}{\left(1 - \dfrac{H}{2}\right)} \quad \cdots \quad \cdots \quad (8)$$

whilst the lowest magnification occurs when $t_2 = +1$, and is equal to

$$\frac{e_1}{e} = jm_1 \frac{1}{\left(1 + \dfrac{H}{2}\right)} \quad \cdots \quad \cdots \quad (9)$$

For both maximum and minimum amplification in the grid circuit the phase angle of the tuned circuit is 45°.

Curves connecting the variation of grid circuit voltages with anode tuning are shown in Fig. 3 for various values of H. In these curves, K_1 (see equation 6) is plotted against t_2, the phase tangent. For any given stage we need to know the values of (*a*) g, the mutual conductance of the valve which can usually be obtained from the maker's curves with sufficient accuracy, or can be readily measured; (*b*) ω, the frequency of the injected signal $\times 2\pi$; (*c*) C_0, the grid-anode capacity which can be obtained as explained in Para. 6 of this paper; (*d*) σ_1 and σ_2, the conductances of grid and anode circuits; and (*e*) m_1, the grid circuit magnification. This can easily be found in this test by shorting the anode load, so that there is no reflected conductance, and measuring the gain due to the grid circuit at resonance.

From these figures H is calculated, thus giving the particular curve of the family to be used. The connection between the phase-tangent t_2 and the capacity change C_a is easily found:

$$t_2 = -\frac{\omega C_a}{\sigma_2} \text{ or } C_a = -\frac{t_2\sigma_2}{\omega} \quad \cdots \quad (7)$$

When we have discovered H for any particular circuit we may read off from the curve corresponding, the fraction of the normal voltage e_1 that is obtained on the grid for any capacity off tune C_a.

Alternatively, the measurement of the maximum, normal and minimum resonant grid voltages that occur as the anode circuit is tuned through its resonant point may be used to give an accurate value for H. As the quantity H is used a good deal in later measurements in this paper, this will be the normal usage for this test.

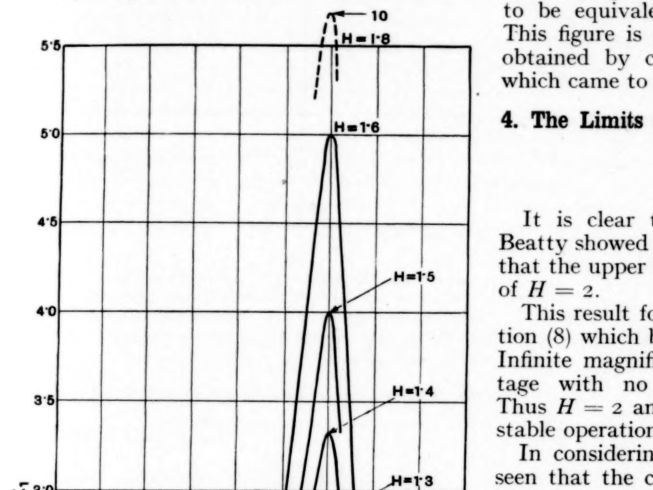

Fig. 3.—*The variation of the voltage on the grid of the valve as the anode circuit is tuned through resonance is shown for various values of the circuit constant H. K_1 is given by the curves for values of t_2 and H, which are themselves determined from the circuit constants :—*

$$(a)\ \frac{e_1}{e} = jK_1m\ .\ (b)\ t_2 = -\frac{\omega Ca}{\sigma_2}\ .\ (c)\ H = \frac{g\omega C_0}{\sigma_1\sigma_2}.$$

The ratio of the maximum to normal voltage $= K_1$ for the curve. From a family of curves as shown in Fig. 3, the value of H is at once determined.

Such a curve of K_1 against t_2 was plotted out for a test amplifier stage and was found, when compared with the family of curves to be equivalent to a value of $H = 0.36$. This figure is in close agreement with that obtained by calculation from the formula which came to 0.37.

4. The Limits of "*H*."

$$H = \frac{g\omega C_0}{\sigma_1\sigma_2}.$$

It is clear that H cannot be negative. Beatty showed by a geometrical construction that the upper limit for stability was a value of $H = 2$.

This result follows at once from the equation (8) which becomes infinite when $H = 2$. Infinite magnification infers an output voltage with no input, *i.e.*, self-oscillation. Thus $H = 2$ and $H = 0$ form the limits for stable operation.

In considering the quantity H it will be seen that the circuits external to the valve contribute the terms σ_1 and σ_2 whilst the injected signal determines ω. There remains a factor gC_0 which depends on the valve construction and working state.

Generally speaking, when C_0 is reduced (by closer screening in the valve) the value of g drops, but not necessarily in the same ratio. It is at once obvious that the quantity g taken from the manufacturer's curves, does not give the whole story of the performance of the valve as an amplifier, since if the valve has also a high value of interelectrode capacity C_0 which the user cannot vary, the product gC_0 may be sufficiently great to make H more than 2, thus causing instability. As the best possible coils are necessarily retained to give optimum selectivity, g must be reduced by raising the grid-bias on the valve to such a value that the stage is again stable, or by loosening the coupling between the valve and its tuned circuits. We are thus unable to make full use of the mutual conductance, and the figure for this, taken by itself has therefore ceased to be of any value.

It would therefore be useful to know the values of the grid-anode capacities of the valves to be used in an amplifier, so that the product gC_0 might be calculated, leading to the value of H.

It should be remarked here that the limit of $H = 2$ only holds for a single stage amplifier. It may be fairly readily shown mathematically, as Beatty showed graphically in the *Proc. Phys. Soc.* (*loc. cit.*) that the limit is progressively lower for more stages. The actual figures are :

No. of stages.	Limit of H
1	2
2	1
3	0.764
4	0.67

5. The Reflected Damping

The change of magnification of the grid circuit may be represented by the assumption of a parallel conductance σ_r across the tuned circuit, which may be positive or negative according as the anode circuit is capacitive or inductive. The value of this conductance may be conveniently deduced as under : Equation (6) gives :

$$\frac{jme}{e_1} = 1 + \frac{Ht_2}{1 + t_2^2} \quad \ldots \quad \ldots \quad (10)$$

But $j.m.e$ is the normal grid voltage when $t_2 = 0$, and there is no effect reflected from the anode side, *e.g.*, with no anode load or with resonant load. We may thus replace $j.m.e/e_1$ by the reciprocal ratio of the tuned circuit conductances for the two cases :

$$\frac{\sigma_1 + \sigma_2}{\sigma_1} = 1 + \frac{\dfrac{g\omega C_0}{\sigma_1\sigma_2} . t_2}{1 + t_2^2} \quad \text{or}$$

$$\sigma_r = \frac{g}{\sigma_2} . \omega . C_0\left(\frac{t_2}{1 + t_2^2}\right) \quad \ldots \quad (11)$$

Now g/σ_2 is the stage gain at resonance of the valve.

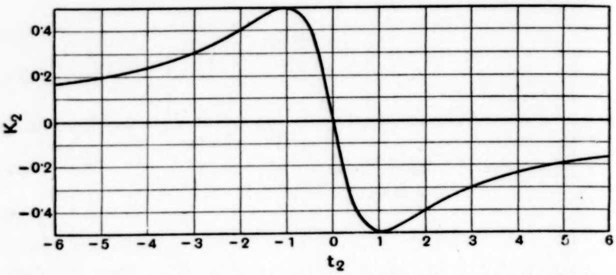

Fig. 3a.—*From this curve the damping reflected on the grid circuit from the anode circuit as the latter is tuned through resonance, can be obtained. The constant K_2 is given for values of t_2, and the damping conductance is then determined from the expression*

$$\sigma_r = \text{stage gain} \times \omega C_0 \times K_2.$$

Note that $t_2 = \dfrac{\omega Ca}{\sigma_2}$ *where C_a is the capacity by which the anode tuning condenser is detuned from its resonant position.*

So $\sigma_r =$ stage gain at resonance . $\omega C_0 . K_2$ where $K_2 = \dfrac{t_2}{1 + t_2^2}$.

In Fig. 3a, a curve is drawn connecting t_2 and K_2. Thus to find the reflected damping conductance we need only to measure the stage gain under the test conditions, and the value of C_0 the anode-grid capacity. For any anode detuning C_a, $t_2 = \dfrac{\omega C_a}{\sigma_2}$, in which expression σ_2 is found from the stage gain and the mutual conductance. Thence K_2 and the damping conductance σ_r can be found.

6. The Capacity Fed Back to the Grid Circuit

It has already been shown in Para 3 that to give a maximum amplification in the grid circuit, it is necessary to detune it from its normal resonant condition at which $t_1 = 0$, to a fresh position such that

$$t'_1 = -\frac{H}{1 + t_2^2}. \quad \ldots \text{(See Eq. 5)}$$

Since this expression is always negative, it corresponds to a reduction of the grid tuning capacity, and infers that the action of a load in the anode circuit is to throw back to the grid circuit a capacity equal to that by which we have to retune. Let this detuning capacity be C_c.

From the above equation we may calculate the capacity that is reflected:

$$t_1' = \frac{1}{\sigma_1}\left(\omega(C_1 - C_c) - \frac{1}{\omega L_1}\right)$$
$$= -\frac{\omega C_c}{\sigma_1} \text{ since } \omega^2 L_1 C_1 = 1.$$

Thus:

$$\frac{\omega C_c}{\sigma_1} = \frac{g\omega C_0}{\sigma_1 \sigma_2} \cdot \frac{1}{1 + t_2^2}$$

or $$C_c = \frac{g}{\sigma_2} \cdot C_0 \cdot \frac{1}{1 + t_2^2} \quad \ldots \quad \ldots \quad (12)$$

Further, it will be observed that g/σ_2 is the stage gain at resonance of the anode circuit, taken from the grid volts to volts developed across the anode tuned circuit.

Hence:

$$C_c = \text{stage gain at resonance} \cdot C_0 \cdot K_3$$

where $K_3 = \frac{1}{1 + t_2^2}$.

In connection with this expression, Fig. 4 is constructed connecting the term K_3 with values of t_2, to which the anode circuit of the stage is tuned. The further connection of t_2 and C_a is given by the expression $t_2 = -\omega C_a/\sigma_2$. (See Eq. 7.)

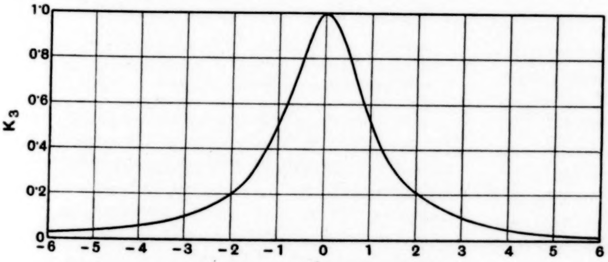

Fig. 4.—*Showing the reflected capacity constant, K_3, as the anode circuit is tuned through resonance. The actual reflected capacity is given by the expressions*

$$t_2 = \frac{\omega Ca}{\sigma_2}$$

Reflected capacity = $K_3 \times C_0 \times$ stage gain at resonance (i.e., when $t_2 = 0$).

Thus for a given circuit we can connect K_3 with the circuit constants ω and σ_2, and the detuning C_a. When the stage gain is measured under the same working conditions, we connect the detuning of the anode circuit with the ratio of the reflected capacity in the grid circuit to the anode-grid capacity.

If the anode-grid capacity is known, then the reflected capacity can be found for all values of the anode detuning C_a.

When used from the reverse point of view the result leads to a simple method for the determination of the very small grid-anode capacity of the valve, and, in fact, has been used for this purpose by other investigators. Its advantage is that the magnitude of the interelectrode capacity is magnified by the stage-gain when measured as the reflected capacity on the grid circuit. This magnification may be of the order 300 or more, thus converting a very small capacity of some 0.005 μμF to a more reasonable value in the neighbourhood of 1.5 μμF, which may be readily measured to some degree of accuracy on a standard condenser.

The practical details are as follows: The grid circuit is tuned to the resonant volt-peak with the anode load shorted, and the retuning of the grid condenser necessary to give a maximum grid voltage when the anode circuit is at resonance is found. Resonance of the anode circuit is readily indicated by the fact that the maximum grid voltage on retuning is the same as that obtained with the anode load shorted.

In the practical case, carried out with the apparatus already described, the value of C_0 was determined at two frequencies for a certain experimental valve. At 110 kc. the stage gain was 250 and the reflected capacity 3.90 μμF, giving a value of $C_0 = 0.0155$ μμF. At 600 kc., the fed-back capacity was 2.3 μμF and the stage-gain 160, giving $C_0 = 0.0145$ μμF, showing a reasonably good agreement with the first measurement.

It is interesting to compare equations (11) and (12). From these we see that for any value of t_2, $\sigma_r = \omega \cdot C_c \cdot t_2$, or reflected conductance = reflected capacity . ωt_2.

This may be further expressed as $t_2 = \frac{\sigma_r}{\omega C_c}$, *i.e.*, the magnitude of the phase angle of the anode load is equal to that of the valve input impedance, but it is displaced 90°.

7. The Variation of the Output Voltage with Circuit Constants

We now turn our attention to the conditions holding in the anode circuit. As Beatty has already done, we eliminate e_1 from equations (1) and (2) giving us the relation between e_2 the output voltage, and e the injected voltage.

$$\frac{e_2}{e} = j \cdot \left(\frac{g}{L_1 \omega \sigma_1 \sigma_2}\right)\left(\frac{1}{(1 + jt_1)(1 + jt_2) + jH}\right)$$
$$= j \,.\, A \,.\, F \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad (13)$$

When $C_0 = 0$, $H = 0$ and the maximum amplification is obtained when $t_1 = t_2 = 0$, and is equal to A. As Beatty showed, A is the maximum amplification without reaction, and F the extra gain obtained by reaction. The complete curves of this function are very laborious to draw as t_1, t_2, and H may all vary independently, and further, since t_1 occurs in both the in-phase and quadrature components, we are not entitled to assume that the amplification is maximum when $t_1 = 0$.

We will thus deal with the maximum values of the ratio only, as these are of the greatest importance. It will be assumed that the applied signal is of such a small value that (for any given circuit conditions) the value of g is constant, so that we may call both A and H constant.

The minimum value of $1/F$ is found by differentiating $(1 + jt_1)(1 + jt_2) + jH$ and equating the differential coefficients simultaneously to zero. For values of H less than 2 there is only one real solution :

$$t_2 = t_1 = t \quad \text{(say)}$$
$$t^3 + t + H = 0 \quad \cdots \quad \cdots \quad (14)$$

which are the conditions for maximum amplification in the stage. This gain thus has a value :

$$\frac{e_2}{e} = j \,.\, A \,.\, \frac{1}{(1 - t^2) + j(2t + H)} \cdots \quad (15)$$
$$= j \,.\, A \,.\, F_0$$

In Fig. 5, a curve is drawn connecting t with H according to equation (14). It will be understood that for any given stage H is a constant quantity and has to be determined. From the curve the phase angle of both the grid and anode circuits for maximum output voltage is read off directly. These phase-tangents are readily convertible into detuning capacities :

$$C_a = -\frac{\sigma_2 t}{\omega} \text{ for the anode circuit,}$$

$$C_c = -\frac{\sigma_1 t}{\omega} \text{ for the grid circuit.}$$

It will be seen from the curve that, for maximum amplification for the stage, both the grid and anode condensers have to be detuned from their resonant conditions.

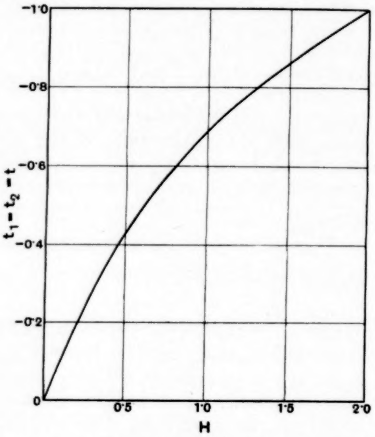

Fig. 5.—*This curve shows the amount of detune necessary in the anode circuit so that the ratio* $\frac{e_2}{e}$ *should be a maximum. The detune is expressed as a phase angle* t_2 *which is readily converted to a detuning capacity, since* $\omega Ca = -t_2\sigma_2$.

Consideration of the grid detuning equations (No. 5) shows that the necessary capacity reduction is consistent with that required for the cancellation of the reflected capacity from the anode circuit, and the grid circuit is thereby re-resonated to the injected frequency. In the case of the anode circuit, however, no such cancellation takes place, and it follows that when a stage such as, for example, an intermediate frequency amplifier, is tuned so as to give maximum output, the grid circuit will be resonant at the correct frequency, but the anode will be resonant at some neighbouring frequency. The selectivity or the cut-off of band-filtering arrangements will thus be affected.

Moreover, the greater the value of the constant H for the circuit, the greater will be the amount of detune.

For a certain test stage at 300 kc. the value of H was found to be 1.2 under the operating conditions, whilst the anode circuit dynamic resistance, including the valve internal path, was 3×10^5 ohms. From the curve Fig. 5, this gives a value of t equal to 0.76, or a phase-angle of 37.5°.

$$\text{Whence } C_a = -\frac{0.76 \times 0.33 \times 10^{-5}}{300{,}000 \times 2\pi} = 1.35\ \mu\mu\text{F}.$$

Since the tuning capacity was about 100 $\mu\mu$F this is a detuning of 1.35 per cent., representing a frequency detuning of 0.67 per cent. or 2 kc. With the present station separation of only 9 kc., this may become a serious matter.

8. The Extra Stage-Gain Due to Reaction

Reference may be made here to the magnitude of the reaction amplification factor F_0. Beatty (*loc. cit.*) in his paper derived a curve by geometrical means connecting F_0 with H. We are in a position to derive a similar and rather more convenient curve directly from equation (15) since the connection between t and H has already been established for the conditions of maximum amplification. Such a curve is plotted in Fig. 6 and from it the gain due to reaction can be read off at once for any value of H. It will be noticed that the actual ordinates represented are the reciprocals of F_0. This is merely for convenience owing to the rapid increase in the value of F_0 as H approaches the value 2.

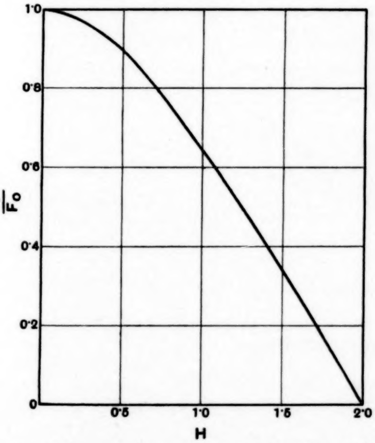

Fig. 6.—*The extra gain on any stage F_0, which is due to the reaction resulting from a grid-anode capacity C_0, can be obtained from the curve above for different circuit constants* $H\left(=\frac{g\omega C_0}{\sigma_1\sigma_2}\right)$.

As an example of the use of this curve, the test valve mentioned in para. 7 had an H-value of 1.2. From the curve the corresponding figure for $1/F_0$ is 0.53 and hence $F_0 = 1.9$.

The overall stage-gain was 160 as measured under the working conditions. Thus the stage gain without any reaction would be 85.

9. The Response Curve of the Stage.

The output voltage variation with change of frequency.

The magnification of the stage is given by equation (13)

$$\frac{e_2}{e} = j \cdot \frac{g}{\omega L_1\sigma_1\sigma_2}\left\{\frac{1}{(1+jt_1)(1+jt_2)+jH}\right\}$$

Let the circuit be tuned to give maximum output at a frequency ω. Then by equations (14) and (15)

$$t_2 = t_1 = t \text{ (say)}$$
$$t^3 + t + H = 0$$

and the magnification is given by :

$$M_{\text{max.}} = j \cdot \frac{g}{\omega L_1\sigma_1\sigma_2} \cdot \frac{1}{(1-t^2)+j(2t+H)}$$
$$= j \cdot A \cdot F_0.$$

Suppose the grid and anode circuits are the same, and the damping of the valve is negligible would be the case with an H.F. pentode ; then $L_1 = L_2$, $C_1 = C_2$, and $\sigma_1 = \sigma_2$.

At a frequency removed $d\omega$ from the tuned frequency ω, A will alter to $(dA + A)$, t to $(t + dt)$ and H to $(H + dH)$.

Then the magnification will be given by :

$$M = j \cdot \frac{A + dA}{1-(t+dt)^2 + j(2t+2dt+H+dH)} \quad \ldots \quad \ldots \quad (16)$$

Further, we find that the overall magnification is reduced by this frequency change in the ratio :

$$\frac{M_{\text{max.}}}{M} = \frac{A}{A+dA}\left\{\frac{1-(t+dt)^2+j(2t+2dt+H+dH)}{(1-t^2)+j(2t+H)}\right\} \quad \ldots \quad \ldots \quad (17)$$

This equation does not lend itself to further simplification owing to the fact that dt may be greater than t so that we may not neglect its second and higher powers. Its form may be seen by directly evaluating the expressions for a characteristic circuit for various values of $d\omega$.

No.	Frequency off resonance (Kilocycles).	$d\omega \times 10^3$	$dH = 6 \times 10^{-7} \cdot d\omega$ $(\times 10^{-3})$.	$dA = 1.015 \times 10^{-2} \times d\omega$	$dt = 50.46 \times 10^{-6} \times d\omega$	Sign of $d\omega$.	Magnification Ratio $\frac{M_{\text{max.}}}{M}$	Amplification without reaction.	Amplification with reaction. $E = 100$v. at $d\omega = 0$.
1	10	62.8	37.68	637.5	3.16	+ −	15.35 32.68	4.59 4.51	6.52 3.06
2	2	12.6	7.536	127.5	0.63	+ −	2.78 3.78	35.8 35.6	36.0 26.4
3	4	25.1	15.07	255.0	1.264	+ −	4.76 8.72	19.3 19.2	21.0 11.5
4	6	37.68	22.61	382.5	1.896	+ −	7.08 15.1	10.98 10.79	14.1 6.64
5	8	50.24	30.14	510	2.528	+ −	10.43 23.18	6.82 6.70	9.58 4.32
6	15	94.20	56.52	956	4.74	+ −	34.62 63.8	2.16 2.10	2.89 1.57
7	20	125.6	75.36	1,275	6.32	+ −	63.7 105.4	1.24 1.20	1.57 0.95
8	30	188.4	113.0	1,912	9.48	+ −	151.3 221.7	0.566 0.533	0.661 0.452
9	50	314	188.4	3,187	15.8	+ −	438 589	0.208 0.189	0.228 0.170
10	100	628	376.8	6,375	31.6	+ −	1,750 2,358	0.055 0.045	0.057 0.042

Fig. 7.—*The derivation of the curves for magnification ratio and voltage output from a stage for constant input, as given in Equation* (17).

Consider firstly the magnitude of the changes dA, dt, and dH for a change of $\omega = d\omega$. To do this it will firstly be necessary to connect the dynamic resistance of the tuned circuits with the frequency ω, since it will vary, and its rate of change must be known. For this example suppose that over the range of frequencies considered the magnification of the tuned circuits is constant, *i.e.*, $\omega L/r$ is a constant. Then the dynamic resistance $\omega^2 L^2/r$ will vary as the frequency ω and may be written $1/k\omega^{-1}$ (thus equating σ to $k\omega^{-1}$). It is to be recognised that the method would hold equally well for any other relation between σ and ω that may be true for any set of circuits at any frequency under consideration.

Using the particular relation in this example we may next connect the other variables with ω as follows:

$$(a) \quad A = g/\omega L k^2 \omega^{-2} \quad = a\omega \quad \ldots \quad (18)$$

$$\text{So } dA = \quad a\,d\omega \quad \ldots \quad (18a)$$

$$(b) \quad H = \frac{g \cdot \omega \cdot C_0}{k^2 \omega^{-2}} \quad = h\omega^3 \quad \ldots \quad (19)$$

$$dH = \quad 3h\omega^2 d\omega \quad \ldots \quad (19a)$$

$$(c) \quad t = \left(\omega C - \frac{1}{\omega L}\right) b\omega = b\omega^2 C - \frac{b}{L} \quad (20)$$

$$dt = \quad 2bC\omega \cdot d\omega \quad (20a)$$

Where a, h and b are constants.

Thus when $d\omega$ is positive, dA, dH, and dt are all positive.

When $d\omega$ is negative, dA, dH, and dt are all negative.

For the evaluation, suppose we have a good average circuit whose constants are as follows:

$\omega = 6.28 \times 10^6$ (*i.e.*, 1 megacycle)
$L = 200 \times 10^{-6}$ Hy.
$\sigma = 5 \times 10^{-6}$ Mhos.
$g = 2 \times 10^{-3}$ Amp./Volt.
$C_0 = 2.5 \times 10^{-15}$ Farad.

Then

$H = 1.256$
$A = 63{,}700$
$t = -0.78$ from Fig. 5
$1/F_0 = 0.496$ (Equation 15)

Then by direct substitution in equations 18a, 19a, and 20a, we arrive at the following:

$$dA = 1.015 \times 10^{-2} \times d\omega \quad \ldots \quad \ldots \quad (21a)$$

$$dH = 6 \times 10^{-7} \times d\omega \quad \ldots \quad \ldots \quad (21b)$$

$$dt = 50.46 \times 10^{-6} \times d\omega \quad \ldots \quad \ldots \quad (21c)$$

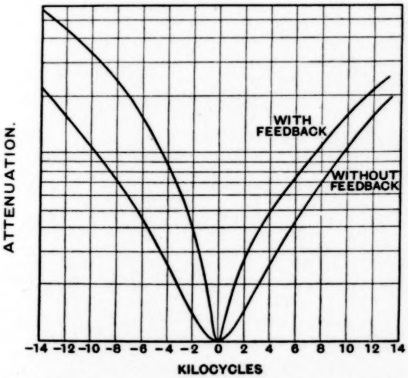

Fig. 8.—*The overall attenuation of a single stage amplifier with and without interelectrode feed-back.*

The complete evaluation of the expression in equation (17) for the ratio of the magnifications is then arrived at as shown in Table Fig. 7, and the response curve shown in Fig. 8 can be drawn.

In order to demonstrate the exact effects of the anode-grid capacity reaction, we now plot the response curve that would obtain if all feed-back were removed. In such a case $C_0 = 0$ and thus $H = 0$; furthermore, from equation (14), $t = 0$.

The expression for the magnification ratio given in equation (17) then reduces to:

$$\frac{M_{\text{max.}}}{M} = \frac{A}{A + dA}\,(1 + 2j\,.\,dt - dt^2) \quad \ldots \quad (22)$$

which on rationalising becomes

$$\frac{M_{\text{max.}}}{M} = \frac{A}{A + dA}\,((1 - dt^2)^2 + 4\,.\,dt^2)^{\frac{1}{2}}$$

$$= \frac{A}{A + dA}\,(1 + dt^2) \quad \ldots \quad \ldots \quad (23)$$

This ratio will thus be very nearly symmetrical for positive and negative values of $d\omega$, the only unsymmetrical term being dA which is small compared with A as long as $d\omega$ is small compared with ω. The curve of the expression in equation (23) is also plotted in Fig. 8.

It will be seen on comparing the two curves that the effect of reaction is firstly to produce an unsymmetrical response, and secondly, to increase the initial rate of falling off of the voltage ratio, particularly on the lower frequency side of resonance.

This is perhaps seen more readily from the curves of Fig. 9, where the actual output voltage is plotted for a constant input voltage to the stage.

Consider firstly the skirts of the resonance curves. It will be seen that they are almost identical as regards slope and band-width for any given output voltage. This is due to the fact that in such positions the circuits are highly reactive and the change of grid circuit resistance due to reaction is then comparatively small. The displacement of the reaction curve BEB' is due to the fact that in order to obtain a maximum response at the frequency ω both grid and anode circuits have to be detuned from the resonant position $\omega^2 LC = 1$ as we have shown in equations (14) and (15).

It will be remembered that at the maximum point E the detuning of the grid circuit balances the reflected capacity and the detuning of the anode circuit gives the optimum position between resonance and maximum negative reflected damping as shown in para. 7.

Returning to our consideration of Fig. 9 we see that at points well off the maximum position, both the reflected damping and the reflected capacity are of little importance and the detuning of the two circuits has the effect of producing a stage with circuits resonating at a frequency higher than ω, the frequency of maximum output. This is equivalent to moving the whole curve ADA' without reaction, bodily to the right to a position BEB' and signifies that the adjacent channel response to stations at frequencies greater than the resonant tuned frequency will be more than that of stations having a frequency lower than the resonant frequency.

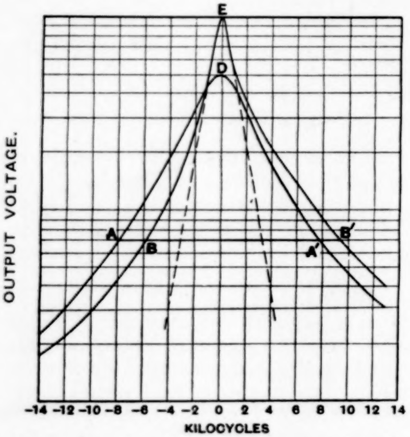

Fig. 9.—*Showing the relative stage gain of a single-stage amplifier with constant input voltage at* 10^6 *cycles/sec.*

ADA' with no feed-back from anode to grid. BEB' with feed-back across anode-grid capacity. The dotted line shows how the initial slope at 1 *kc. off resonance is increased.*

Turning now to the position in the immediate neighbourhood of maximum output E we see that the effects of reaction are to increase the output from D to E (by a factor F_0) and to sharpen the response curves due to the reflected negative damping to the grid circuit which, owing to the huge reduction of the tuned circuit reactances on approaching resonance, has now become of considerable importance.

The response curve at 1 kilocycle off tune has a slope such as is shown by the chain line in the figure, which can readily be compared with the corresponding slope for the case where there is no feed-back on the curve ADA'.

10. A Suggested Sequence of Tests on an Amplifier Stage

In conclusion it is suggested that a suitable sequence of tests on an amplifier stage might be as follows :

(*a*) Measure the maximum and minimum grid voltages for constant input on a resonant grid circuit as the anode circuit is tuned through resonance. Measure the normal voltage with no anode load. From these the values of $K_{1\text{max.}}$ and $K_{1\text{min.}}$ are found and H follows from comparison with the set of curves in Fig. 3 (para. 3.)

(*b*) Measure the maximum reflected capacity and the stage gain corresponding whence the value of C_0 is found (para. 6.)

(*c*) By direct application of C_0 the damping conductance reflected on the grid circuit is found (para. 5.) The maximum reflected conductance occurs when $t_2 = \pm 1$, *i.e.*, $K_2 = \pm 0.5$, thus giving the value of the maximum reflected conductance. Otherwise from Fig. 3a.

(*d*) The detuning of the anode and grid circuits follows at once from Fig. 5. H has already been determined. See also para 7.

(*e*) From Fig. 6, and knowing the values of H, the stage-gain due to reaction and thence that due to simple amplification are obtained directly. See also para 8.

APPENDIX I

The following is a list of the symbols used in the text. As the work is in several ways allied to that of Beatty (*loc. cit.*), the same symbols have been used wherever possible, to facilitate the connection between them.

e = Voltage introduced into the grid circuit.
e_1 = Voltage on the grid of the valve.
e_2 = Voltage developed across the anode tuned circuit.
μ = Valve amplification factor.
g = Valve mutual conductance.
ω = Frequency of induced signal × 2π.
C_g = Grid condenser capacity.
C_c = Grid detuning capacity to balance the fed-back capacity.
C_p = Anode condenser capacity.
C_a = Anode detuning capacity.
C_0 = Anode-Grid interelectrode capacity.
C_1 = Effective grid tuning capacity $= C_g + C_0$.
C_2 = Effective anode tuning capacity $= C_p + C_0$.
σ_p = Conductance of anode tuned circuit.
σ_v = Conductance of valve.

σ_2 = Effective conductance of anode circuit $= \sigma_p + \sigma_v$.

σ_1 = Effective conductance of grid tuned circuit.

σ_r = Conductance reflected from anode to grid circuit.

t_1 = Tangent of phase angle of grid tuned circuit $= \left(\omega C_1 - \frac{1}{\omega L_1}\right)\frac{1}{\sigma_1}$.

t_2 = Tangent of phase angle of anode tuned circuit $= \left(\omega C_2 - \frac{1}{\omega L_2}\right)\frac{1}{\sigma_2}$.

L_1, L_2 = Inductances of coils used in tuned circuits.

$j = \sqrt{-1}$.

$A = \frac{g}{\omega L_1 \sigma_1 \sigma_2} \qquad H = \frac{g \omega C_0}{\sigma_1 \sigma_2}$

$F = 1/[(1 + jt_1)(1 + jt_2) + jH]$

t_1' = Special value of t_1 to bring the grid circuit to resonance.

m_1 = Magnification of grid tuned circuit $= \omega L_1 / r_1$.

$$K_1 = \frac{1}{1 + \frac{Ht_2}{1 + t_2^2}}.$$

$$K_2 = \frac{t_2}{1 + t_2^2}.$$

$$K_3 = \frac{1}{1 + t_2^2}.$$

New Telefunken Magazine

THE Telefunken Company has for the last fifteen years issued a magazine, *Telefunken Zeitung*, dealing with all branches of radio work. They have now begun the issue of an additional magazine, devoted entirely to valves and their associated circuits. This new magazine, the first volume of which was issued in July, is known as *Die Telefunken-Röhre*, and is edited by Dr. Rukop. It contains 44 pages and in addition to an introductory note by Dr. Rukop contains four articles; the first a general one entitled "Progress," the second, and principal, one on stray electrons in amplifying valves, the third on the reasonable and unreasonable use of valves in receivers, a protest against stunt circuits necessitating the selection of special valves of very accurate characteristics, and finally a description of a 300 kilowatt valve. The article on stray electrons deals with the effect of electrons which escape from the normal path and, instead of arriving at the anode, strike the ceramic insulating material used to support the electrodes and, under certain circumstances, cause the emission of secondary electrons in sufficient quantity to interfere with the functioning of the valve. Certain cases of instability have been traced to this cause, to avoid which metal screens are being inserted to prevent stray electrons from getting to the insulating material.

G. W. O. H.

OLYMPIA RADIO SHOW, 1934.—*A general view of the Main Hall, Olympia, on the opening day of the Radio Show. An illustrated report on matters of technical interest exhibited will appear in our next issue.*

The Design of A.V.C. Systems

A Discussion of D.C. Amplified A.V.C.

By W. T. Cocking

(Continued from page 414 *of last month's issue)*

Distortion with Delayed A.V.C.

APART from overloading effects, there are two possibilities of distortion with delayed diode A.V.C. which do not occur in the simple non-delayed system. In the first place, consider Fig. 8 and assume that there is a large input to the detector. This being so, L.F. potentials will appear across the resistance R_3 as well as the desired steady bias potential, and these are prevented from reaching the controlled valves by the usual filter R_4 and C_2. The L.F. potentials, however, may be transferred to the detector diode through C_1,—C_1 and R_1 acting as an ordinary resistance-capacity coupling. If the potentials across R_3 were an exact copy of those developed across R_1 by the action of the detector diode, there would be no transference, for both sides of C_1 would be at the same instantaneous potential. They are not the same, however, for the input to the delay diode is smaller than that to the detector diode by the drop in C_1, and the delay voltage necessarily means that the modulation potentials across R_3 are distorted, except perhaps for shallow modulation. As a result, distorted modulation frequency potentials may appear across R_1 and be passed through to the L.F. amplifier, since the impedance of L is negligible at modulation frequencies.

The seriousness of this will depend largely upon the values assigned to R_1 and C_1, and with the usual values will be negligible at low frequencies. It may assume serious proportions at high modulation frequencies, however, for C_1 cannot be reduced too far without A.V.C. being appreciably affected. Fortunately, this difficulty can be got over fairly simply, by feeding the A.V.C. diode from the primary of the I.F. transformer instead of from the secondary as in Fig. 8. This also leads to the A.V.C. diode input being slightly increased and also tends to equalise the loading on the I.F. transformer windings.

There is, however, another important advantage to be secured through feeding the A.V.C. system from the transformer primary, and this is one which is to be found with any system. It is well known that the sensitivity of a receiver equipped with A.V.C. increases as the tuning is varied away from a station, with the result that an unpleasant screech is found when a selective set is momentarily tuned only to the sidebands of a station. The more selective the set, the more unpleasant is this effect, and in the absence of special silencing devices it can be avoided only by reducing the selectivity of the set so that there is sufficient carrier voltage reaching the A.V.C. system to hold down the sensitivity although the circuits are mis-tuned. Now if the A.V.C. system be fed from the primary of the last I.F. transformer and the detector from the secondary, the degree of selectivity preceding the A.V.C. circuits is less than that before the detector, with the result that when the set is mistuned from a station the carrier sets up a greater voltage at the A.V.C. rectifier than at the detector. The sensitivity, therefore, is less than it would be if the A.V.C. bias were derived from a rectifier connected to the transformer secondary. Quieter A.V.C. is thus obtained by feeding the A.V.C. system from the last transformer primary.

The second possibility of distortion with delayed A.V.C. comes about through the A.V.C. bias voltage being affected by the modulation of the carrier instead of being dependent only on the mean carrier amplitude. This form of distortion is distinct from that described when dealing with the simple diode system, the avoidance of which depends on the use of a sufficiently high time constant for the filter circuit R_4 and C_2 of Fig. 8. The additional type of distortion with delayed A.V.C. is not confined to the delayed diode system, but is common to most methods, and is probably best described as a modulation peak effect.

Referring to Fig. 12, it will be seen that if the unmodulated carrier amplitude has a value AB slightly less than the delay voltage on the A.V.C. diode, there is no rectification and no A.V.C. bias is produced. If the carrier be modulated, however, during the peaks of modulation it assumes a maximum value AC which is greater than the delay voltage, and a minimum value AD which is less than the delay voltage. During the time of no modulation and during the troughs of modulation there is no production of A.V.C. bias, but during the peaks of modulation there are momentary pulses of current through the diode load resistance. Modulation, therefore, gives rise to a pulsating E.M.F. across the load resistance. This is largely smoothed out by the filter circuit so that the bias which is applied to the controlled valves is not necessarily pulsating. The point of importance, however, is that the controlled valves are biased to some extent by a modulated carrier whereas they would not be with an unmodulated carrier of the same amplitude. Thus A.V.C. is not actuated entirely by the carrier amplitude, but depends to some degree also upon the modulation depth. This would be unimportant if the modulation consisted of a single pure note of unvarying amplitude, but during an average broadcast programme it means that whenever the modulation depth rises above a certain figure, which depends on the design of the receiver and the particular conditions under which the receiver is being worked, the bias on the controlled stages rises above its normal value and reduces the sensitivity of the set. The natural consequence of this is a tendency for loud sounds to be reproduced somewhat below their proper strength.

It is probable that in practice this effect is not very important, and the writer cannot point to any case in which audible distortion has been traced to this cause. It is highly probable that it is completely negligible in all cases where only the ordinary standard of quality is aimed at, but it is a point to be born in mind where the highest quality of reproduction is important.

Before passing on to a consideration of improved methods of A.V.C. it may be as well to point out one serious pitfall into which the designer of a superheterodyne may fall, whatever method of A.V.C. be embodied. *It is essential that the frequency stability of the oscillator should be unusually good.* It is obvious that if the frequency of the oscillator varies with the bias on the controlled stages the I.F. circuits will be, in effect, mis-tuned from the carrier whenever the bias varies from the value applied when tuning was carried out. The reception of a fading signal, therefore, will be accompanied by a serious amount of distortion and the volume may not remain constant, however perfect the A.V.C. system itself may be. The effect is at its worst with a very selective I.F. amplifier, and it would only be negligible if the I.F. amplifier as a whole had true band-pass characteristics with a pass-band considerably wider than the frequency variations of the oscillator.

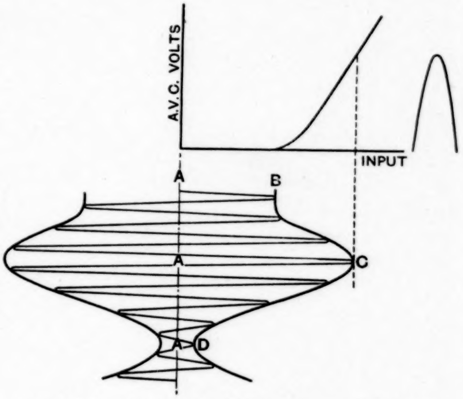

Fig. 12.—*Illustrating the dependence of A.V.C. bias upon modulation.*

The trouble occurs usually not so much through the effect of varying the grid bias itself as through a secondary effect. A falling anode current for the controlled stages with increasing A.V.C. bias gives an increasing voltage output from the mains equipment, since the regulation is never perfect, with the result that the oscillator anode voltage is also increasing. Unless the oscillator circuits are designed so that the maximum variation in anode voltage causes a negligible change in frequency, therefore, automatic volume control will be unsatisfactory for the reception of a fading station. Since one of the chief uses of A.V.C. is to counteract fading, the importance of this effect cannot be too highly stressed.

One remedy, of course, is to design the oscillator so that its frequency is largely unaffected by changes in its supply potentials, and this is always desirable in order that operation may not be affected by variations in the supply mains themselves. In general, however, it is more convenient to obtain stability through the careful design of the mains equipment. For a given change in anode current of the controlled valves, the aim should be to make the oscillator anode voltage vary as little as possible. In the case of a heptode type frequency-changer one would at first expect the stability to be worse than with a two-valve type. The tetrode portion of the valve is usually controlled from the A.V.C. system and the screen potential often varies over a wide range with a change in A.V.C. bias. Since one portion of the screen is immediately adjacent to the oscillator anode in the electrode assembly, one would expect that a variation in its potential would exercise a very marked effect upon the oscillator frequency.

Preliminary experiments have been carried out to see whether the effect is marked, and it is hoped to deal with the matter in detail at a later date. At the time of writing, however, it appears that the frequency variation may be considerable with certain valves but negligible with others. The tests were carried out with apparatus giving poor regulation for the screen feed, the screen potential actually varying from 100 volts at –3 volts grid bias to 150 volts at –40 volts bias. With a heptode of one make the oscillator frequency changed by some 1,000 cycles on varying the bias over this range, but with a different make of valve no frequency change could be detected. It would seem, therefore, that with a well-designed valve the variations in screen voltage and oscillator anode voltage can be made to compensate one another, and that the frequency will then be independent of grid bias.

D.C. Amplified A.V.C.

Returning to A.V.C. systems themselves, it can be seen from a consideration of the failings of the simple and delayed diode methods that the chief requisite is a bias voltage which is greater than the rectified output of the last H.F. or I.F. controlled amplifier valve, for otherwise this last valve will be called upon to give a large output at a high bias voltage, and present day valves will not do this. Two alternatives present themselves—an extra stage of H.F. or I.F. amplification can be used solely for feeding the A.V.C. diode or the output of the diode rectifier can be amplified before it is used as grid bias. The second alternative is probably the more popular, and it will now be considered.

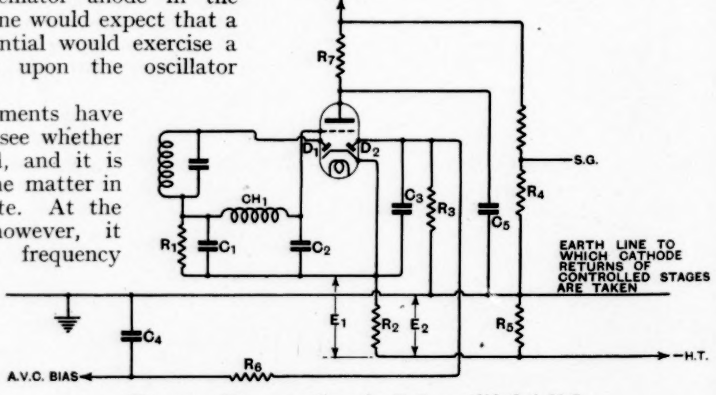
+H.T.
R7
D1
D2
S.G.
C3
R3
C5
R4
CH1
R1
C1
C2
EARTH LINE TO WHICH CATHODE RETURNS OF CONTROLLED STAGES ARE TAKEN
E1
R2
E2
R5
C4
R6
A.V.C. BIAS
-H.T.

Fig. 13.—*The connections for D.C. amplified A.V.C.*

The essential connections so far as A.V.C. is concerned are shown in Fig. 13, and a duo-diode-triode valve is used. It will be noted that the triode load resistance R_2 is connected in the valve cathode circuit. Now in the absence of a signal the triode grid will take up a potential about –0.7 volt negative with respect to the cathode, due to the grid current flow along the diode load resistance R_1. The steady current through R_2, therefore, will be determined by the constants of the valve, the supply voltage, and the value of R_2 itself. When a signal is applied, rectification occurs in the diode D_1 circuit with the result that a steady negative potential is applied to the triode grid, the input being assumed unmodulated and the H.F. or I.F. potentials being filtered out by the combination of Ch_1 with C_1 and C_2. With the increased negative grid potential, the triode anode current falls, and the voltage drop across R_2 is decreased. The cathode potential, therefore, becomes increasingly less positive with respect to negative H.T. as the signal input increases.

The cathodes of the controlled stages are returned through their initial biasing resistances to what we may conveniently term the earth line, since it is the point to which the earth is usually connected and is often the chassis of the set. The grids are also returned to this line through the filter resistance R_6 and the delay diode load resistance R_3. In the absence of a current flow through these resistances, therefore, the grids are at the same potential as the earth line. The earth line is maintained at a potential positive with respect to negative H.T., but, in the absence of a signal, negative with respect to the duo-diode-triode cathode, by means of the resistances R_4 and R_5 connected across the H.T. supply.

When the signal input is small, therefore, the duo-diode-triode cathode becomes less positive and approaches the potential of the earth line, but nothing else happens. When the application of a stronger signal makes the cathode negative with respect to the earth line, however, the diode D_2 comes into action. As long as the cathode is positive with respect to the earth line, this diode is non-conductive, but as soon as the cathode assumes a lower potential than the earth line it becomes conductive. The internal resistance of D_2 and R_3 then form a potentiometer connected between the cathode and the earth line, and since the internal resistance of D_2 is small compared with R_3, practically the full potential difference appears across R_3, and is thus communicated as grid bias to the controlled valves through the usual filter R_6 C_4 It is sometimes convenient to think of the action of D_2 as that of a single-pole make and break switch which closes as soon as the cathode becomes negative with respect to the earth line.

It will be noted that when the carrier is modulated the full modulation frequency potentials which appear across R_1 as a result of rectification in D_1 are applied to the triode grid. An amplified copy of these, therefore, appears across R_2, and the system can thus be used to give signal rectification and first stage L.F. amplification as well as delayed amplified A.V.C. The connections for this appear in Fig. 14 and the point of chief importance to note is the method of obtaining volume control which permits the L.F. potentials applied to the triode grid to be varied without affecting the steady grid potential. The volume control R_2 is often given a value of 250,000 ohms, and R_1 is then usually about 2 megohms.

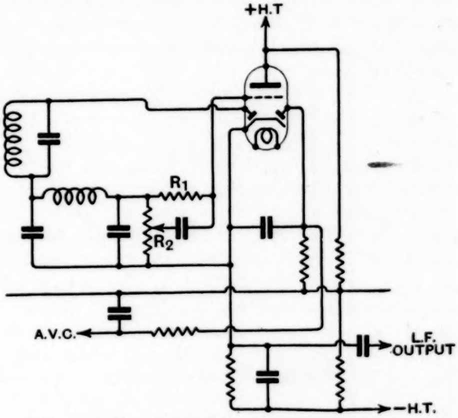

Fig. 14.—*D.C. amplified A.V.C.; the triode acts also as an L.F. amplifier.*

An inspection of Fig. 13 will show that if E_1 is the cathode potential in the absence of a signal and E_2 the earth line potential, both with respect to negative H.T., then the delay voltage is equal to their difference. The maximum A.V.C. bias required by the controlled stages can be calculated exactly as for the Delayed Diode A.V.C. System already described, and for a first approximation the delay voltage should be equal to it if the detector input change is to be restricted to 6 db. The design problem, therefore, usually resolves itself into determining the values of E_1, E_2, R_2 and R_7, for the total H.T. supply is often fixed by other considerations.

The procedure is best illustrated by an example, and we shall suppose that the total H.T. supply is 245 volts, and that the early valves require 200 volts for their operation. Since these early valves are connected between the earth line and positive H.T., E_2 is at once fixed at 45 volts. R_5 can be calculated, therefore, if the total current between the earth line and negative H.T. is known, as will usually be the case for it is merely the sum of the currents taken by the individual early stages and the screen-feed potentiometer R_4.

Assuming the same values for a change of aerial input as before, we require 13.5 volts maximum A.V.C. bias with three controlled stages of amplification. The delay voltage, therefore, should be 13.5 volts, so that $E_1 = 45 + 13.5 = 58.5$ volts. It only remains to settle the values of R_2 and R_7. The amount of amplification obtainable from the valve, both for the bias voltage and for the modulation frequencies, depends upon the value of R_2, so that it is best tentatively to select its value upon the usual basis for an amplifier. Suppose we try 20,000 ohms, since experience shows that this leads to good amplification at modulation frequencies combined with a good frequency characteristic without necessitating any special precautions for the avoidance of stray capacities.

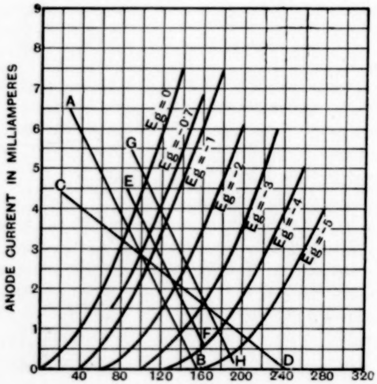

Fig. 15.—*Triode anode-volts/anode-current curves.*

If R_2 is 20,000 ohms and E_1 is 58.5 volts, the anode current of the valve with no signal must be 2.92 mA., so that we can determine the voltage between the valve anode and negative H.T. by drawing a 20,000 ohms load line on the valve curves through an anode current of 2.92 mA. for a grid potential of -0.7 volts. This is represented by the line *AB* of Fig. 15, and we find that the potential required is 157 volts; the drop across R_7, therefore, must be $245-157 = 88$ volts, and the value of R_7 becomes 30,000 ohms.

Now, owing to the presence of R_7, the load on the valve to direct currents is not merely the normal load resistance R_2, but it is the sum of these two resistances; only the voltage developed across R_2 is used, however. The total D.C. load is 50,000 ohms, so that we can draw the load line from the full H.T. potential of 245 volts, and we get the line *CD* of Fig. 15. From this we can read off the anode current for different grid potentials, and by multiplying the currents by the value of R_2, 20,000 ohms, we can obtain the voltage drop along R_2, and this is shown plotted in Fig. 16. It is not a straight line owing to the curvature of the valve characteristics.

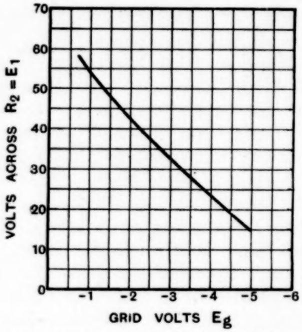

Fig. 16.—*Variation of cathode potential with triode grid voltage.*

By deducting E_2 from these figures we obtain the cathode potential with respect to the earth line, and if we assume that the delay diode has negligible internal resistance, this is equal to the A.V.C. bias, provided that we ignore values which are positive with respect to the earth line, for then the delay diode is non-conductive. We thus obtain the curve of Fig. 17 showing the relationship between the triode grid potential and the A.V.C. bias. We can now read off the extremes of triode grid bias, which is derived from the rectified signal, for the limits of input. When A.V.C. just commences to operate, the bias is -1.75 volts, and for the maximum A.V.C. bias required (-13.5 volts) it is -3.1 volts. The next step is to find the H.F. or I.F. input to the diode required to produce these figures; Fig. 5 shows that for a bias of -1.75 volts on the triode grid the input must be 2 volts R.M.S. and for a bias of -3.1 volts the input must be 3.1 volts R.M.S. since the diode characteristics are non-linear for such small inputs.

This means that the detector input change is only 3.8 db. for a change of amplification of 100 db., instead of the 6 db. which we initially laid down. As a result, the detector input rises by 3.8 db. for a rise in aerial input of 103.8 db. against the rise of 6 db. for a change of input of 106 db. It is obvious, therefore, that this system of A.V.C. will easily fulfil the conditions, and at first sight it appears to be entirely satisfactory.

No difficulties occur in regard to overloading of the valve preceding the detector, for the maximum detector input is 3.1 volts R.M.S., and even on 80 per cent. modulation the peak carrier amplitude will not rise above 7.75 volts. The moderate detector input also means that less H.F. or I.F. amplification is needed; for a given over-all amplification, amplified A.V.C. permits a reasonable proportion to be obtained after rectification. The chief disadvantage of the arrangement is the necessity for a source of potential negative with respect to the earth line of the receiver. Although this may sometimes be obtained by utilising the drop across the field winding of a moving-coil loud speaker which is connected for smoothing purposes in the negative H.T. lead, it is usually inconvenient. Smoothing seems only fully effective when it is used in the positive lead, and negative H.T. must usually be at earth potential if hum is to be avoided. Electrolytic condensers are now widely used for smoothing and by-passing purposes; as usually constructed contact is made to their negative terminals by bolting them to a metal chassis with the result that, if the chassis is not at the same potential as negative H.T., certain condensers may have to be provided with a special insulating mounting.

Apart from this, if the system be used purely for A.V.C. purposes and is not used also to provide signal rectification and first stage L.F. amplification, there is only one objection to the arrangement. Experience has shown that when the filter R_6 C_4 is given normal values the system functions satisfactorily for the usual magnitudes of aerial input. When the receiver is tuned to a strong signal, however, in many cases an effect similar to motor-boating occurs. That this is not due to H.F. or I.F. currents in the A.V.C. line causing instability through insufficient filtering is proved by its occurring only on strong signals when the controlled valves are heavily biased. The cause of the trouble does not seem to have been found yet, but a cure is known. If C_4 be increased to about 2μF. the trouble usually ceases, but increasing R_6 proportionately does not effect a cure. In practice, of course, C_4 cannot be increased so greatly because the time constant becomes very high and A.V.C. operates much too slowly for pleasant tuning or for smoothing out high speed fading.

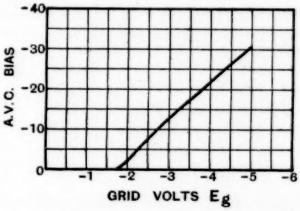

Fig. 17.—*Bias voltage available for various grid voltages.*

If the duo-diode-triode be used as an L.F. amplifier as well as an A.V.C. system more careful design is required, otherwise distortion may occur on a strong signal. The amplifier conditions are readily determined in the usual way from the curves of Fig. 15, remembering that the load impedance to modulation frequencies is equal to R_2, or in our case 20,000 ohms. At A.V.C. threshold the bias voltage developed on the triode grid is 1.75 volts, so that the peak modulation frequency voltage for 80 per cent. modulation is 1.4 volts. The line EF on Fig. 15 represents a 20,000 ohms load for a grid potential corresponding to A.V.C. threshold, and it will be seen that the amplification is 17.85 times and the distortion due to second harmonic is 3.41 per cent.

At maximum input the bias is 3.1 volts, the maximum L.F. input 2.48 volts peak and the load line moves to GH; if the full voltage be applied to the triode grid, the distortion will rise to about 11.3 per cent.

This is a very serious amount, but in practice the full input would not usually be applied, for the setting of the manual volume control would be reduced. It could, of course, be largely avoided by re-designing the system so that the valve is operating with a higher anode voltage. This would mean a reduction in the value of R_7 and a modification either to R_2 or to the delay voltage. In general, it is considered satisfactory if the voltage E_1 across R_2 is made at least 2.5 times the delay voltage.

D.C. Amplified A.V.C. is thus not without its drawbacks, and it may be remarked that the peak modulation effect described for Delayed Diode A.V.C. is still present. L.F. potentials appear across R_2, so that the cathode potential is fluctuating with respect to the earth line. When the mean cathode potential is only slightly positive with respect to the earth line, therefore, it will become momentarily negative during the peaks of modulation and the delay diode D_2 will become momentarily conductive and permit pulses of bias to be applied to the controlled valves.

When considering the use of a system of this nature, it must be remembered that the delay voltage may depend largely on the characteristics of the valve employed. As this valve loses its emission after considerable use, therefore, the delay voltage will fall and the operation of A.V.C. will be affected. Furthermore, two valves are never exactly alike, so that changing the valve will affect the delay voltage somewhat, but the higher the delay voltage used, the less likely is this to be important.

(*To be concluded.*)

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

De-coupling Efficiency

To the Editor, The Wireless Engineer

SIR,—If Mr. Clarke wishes to apply the general form of the expression for de-coupling efficiency which I gave in my letter published in your November issue to the complete solution of some specific problem, he must blame his application of it rather than the fundamental formula, if he finds results do not come up to expectations.

I wrote my original letter on de-coupling efficiency in order to point out a mistake in an article on this subject, since I disagreed with the author's expression in its most general form. It so happened that in the figure used to illustrate the point in question grid de-coupling was taken as an example, and the expression I obtained for the de-coupling efficiency was based (as quite clearly stated) on the reduction of unwanted voltage on the grid of the valve. I might just as easily have chosen anode or any other form of de-coupling and still got the same general answer for de-coupling efficiency. No mention either of anode load or of valve amplification is made, and so obviously no attempt at attaining the overall efficiency of the arrangement. Why then does Mr. Clarke waste so much sarcasm in disproving something at which no attempt at a proof has been made ?

If, however, he sets out so vindictively to prove that manufacturers just sprinkle de-coupling condensers about in their receivers merely because they do no harm, let him consider the case, for instance, of an auto transformer coupling to the grid of the next valve. Resultant hum voltage (assuming a high primary impedance) is given by $E - Zia$. Thus, since Zia is less than E, the very fact that ia increases with increase in de-coupling efficiency (as Mr. Clarke takes so much trouble to demonstrate) is, in point of fact, all to the good. In fact, if we could increase the de-coupling efficiency to more than 100 per cent. (*i.e.*, introduce re-generation which will have the effect of decreasing the valve impedance) we could make $E = Zia$, and so theoretically get no hum whatever—not that I recommend this course to anyone.

London, W.2. R. I. KINROSS.

The Frequency Analysis of the Heterodyne Envelope

To the Editor, The Wireless Engineer

SIR,—The Fourier Analysis of the envelope of interference pattern produced by the heterodyning of two radio-frequency waves has been treated in this journal by Mr. Colebrook (April 1932, p. 195) ; his results are given as infinite series. It may be of interest to show that the coefficients of the Fourier series may be also given in terms of Complete Elliptic Integrals of the first and second kind.

The problem is to express

$$(1 + 2r\cos\theta + r^2)^{\frac{1}{2}}$$

as a Fourier series of the form

$$\tfrac{1}{2}a_0 + \sum_1^\infty a_n \cos n\theta$$

The coefficients are given by

$$a_n = \frac{2}{\pi} \cdot \int_0^\pi (1 + 2r\cos\theta + r^2) \cos n\theta d\theta$$

Putting $2\phi = \theta$ and $k^2 = 4r\ (1 + r^2)$

then $$a_n = \frac{4(1+r)}{\pi}\int_0^{\pi/2}(1 - k^2\sin^2\phi)^{\frac{1}{2}} \cos 2n\phi d\phi$$

The problem now resolves itself into evaluating the definite integral $\int_0^{\pi/2}(1 - k^2\sin^2\phi)^{\frac{1}{2}} \cos 2n\phi d\phi$ which will be called W_n.

A reduction formula relating successive W's can be obtained in the following way :—

Write $\triangle = \sqrt{1 - k^2\sin^2\phi}$ and consider the expression $\frac{d}{d\phi}(2\cos 2m\phi \sin 2\phi\triangle^3)$. Performing the differentiation and making a few simple trigonometrical transformations

$$\begin{aligned}\frac{d}{d\phi}(2\cos 2m\phi \sin 2\phi\triangle^3)\\ = k^2\left\{\frac{m}{2} + \frac{5}{4}\right\}\cos 2(m+2)\phi \,.\, \triangle\\ + 2(m+1)\left(1 - \frac{k^2}{2}\right)\cos 2(m+1)\phi \,.\, \triangle\\ - \frac{k^2}{2}\cos 2m\phi \,.\, \triangle\\ - 2(m-1)\left(1 - \frac{k^2}{2}\right)\cos 2(m-1)\phi \,.\, \triangle\\ + k^2\left(\frac{5}{4} - \frac{m}{2}\right)\cos 2(m-2)\phi \,.\, \triangle .\end{aligned}$$

Now, on integrating both sides of this identity with respect to ϕ between the limits O and $\pi/2$, we have

$$\begin{aligned}O = W_{m+2} \cdot \left(\frac{m}{2} + \frac{5}{4}\right)k^2\\ + W_{m+1} \,.\, 2(m+1)\left(1 - \frac{k^2}{2}\right)\\ - W_m \cdot \frac{k^2}{2}\\ - W_{m-1} \,.\, 2(m-1)\left(1 - \frac{k^2}{2}\right)\\ + W_{m-2} \cdot \left(\frac{5}{4} - \frac{m}{2}\right)k^2\end{aligned}$$

a reduction formula relating any five successive W's.

But W_0 is known, for it is the complete elliptic integral E of the second kind.

If we write $\cos 2\phi = 2\cos^2\phi - 1$ then W_1 breaks up into two known integrals and its value is

$$W_1 = \frac{2 - k^2}{3k^2}E - \frac{2(1 - k^2)}{3k^2}K$$

where K is the complete elliptic integral of the first kind to modulus k.

If now we put $m = 0$ in the above reduction formula and notice that $W_r = W_{-r}$ we obtain W_2.

Similarly W_3 is next obtained by putting $m = 1$ and so on.

A. C. Bartlett.

The Research Laboratories of the
General Electric Co., Ltd.,
Wembley, England.

A.V.C. Systems

To the Editor, The Wireless Engineer.

Sir,—In his article on A.V.C. systems, Mr. W. T. Cocking states that when receiving the local station on a receiver having low I.F. gain the I.F. valve may attenuate and the preceding valves may be more seriously overloaded than the I.F. valve.

But if the I.F. valve is attenuating then its input is greater than the sum of the I.F. bias and delay voltage together. It will hardly be possible to produce worse overloading than this and so it can surely be taken as axiomatic that the I.F. valve supplying the A.V.C. rectifier must never be attenuating.

Quite apart from this however it is rarely found that the I.F. valve will give a sufficient output free from distortion if it is fully controlled and so this stage is usually controlled partially only—but to avoid I.F. overloading—not overloading of any preceding stage.

Cambridge. C. J. Carter.

Sir,—Mr. C. J. Carter's suggestion that it should be considered axiomatic not to operate the valve feeding an A.V.C. rectifier in an attenuating condition is of importance in that it will normally lead to a state in which no controlled valve is overloaded. I would like to point out, however, that my statement to which he takes exception, that more serious overloading may occur in an earlier stage, is justified by experimental work on receivers of unusual design.

Suppose that two stages of amplification are used preceding the A.V.C. rectifier and that both are fully controlled from the A.V.C. system. If the valves have similar characteristics and the first stage gives the same or a smaller initial gain than the second, then when the first stage is attenuating the second is also. Hence the input to the first stage is greater than that to the second, and if the latter be overloaded the first will be overloaded more seriously.

London, N.14. W. T. Cocking.

The Industry

Marrison and Catherall, Ltd., Fornsett Street, Sheffield, 4, undertake the manufacture of permanent magnets of all types.

"Measuring and Testing Equipment for the Electrical and Communication Industry" is the title of a new publication issued by Muirhead and Co., Ltd., Elmers End, Beckenham, Kent.

This year's Osram Valve Guide is in the form of a handy pocket-book, which contains technical data, circuit diagrams, abacs, etc.

All communications for Everett, Edgcumbe and Co., Ltd., should now be addressed to Colindale Works, Hendon, London, N.W.9, where the Technical and Sales staff are now concentrated.

Notes on Screened Grid Pentode Detectors*

By F. R. W. Strafford

THE screened grid pentode valve has been designed ostensibly for the amplification of radio frequency potentials; but it so happens that, under certain operating conditions, it exhibits remarkably good rectifying characteristics, producing considerable sensitivity and linearity in operation.

The Ideal Rectifying Characteristic

The ideal rectifying characteristic, expressed as the relationship between applied potential and resultant current, is well known. This function is a straight line of slope K, but it is a discontinuous function in that it becomes zero at $v = 0$ and remains at zero for any further negative increment of v. Such a curve is depicted in Fig. 1*a*, although it is quite in order to assume that the same ultimate effect will be produced by the dotted curve. Similarly, in Fig. 1*b*, a signal may be operated at X to produce the same ultimate effect.

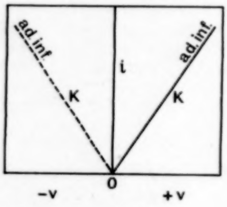

Fig. 1*a*.

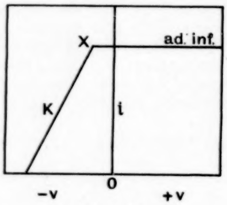

Fig. 1*b*.

Unfortunately such curves cannot be obtained in practice. The slope is not constant over the operating range and the function does not turn to a limiting value with infinite rapidity. Such discontinuities are merely, in this problem, convenient mathematical abstractions whereby the process of rectification may be classically analysed.

Output from an Ideal Rectifier

Assuming that the initial applied potential is a linearly modulated signal in which both carrier and modulation frequencies are sinusoidal, the perfect rectifier will give the following current components:—

1. A direct current increment which is directly proportional to the peak value of the carrier voltage then unmodulated.

2. The carrier frequency plus an infinite series of harmonics of this frequency with progressively diminishing amplitude.

3. The modulator frequency.

(1) is of importance in A.V.C. work and also has a bearing upon the rectifier to be discussed.

(2) is of no use and is conveniently filtered away by condensers and H.F chokes.

(3) is the desired component which, in the ideal case, as expressed above, is undistorted since no harmonic series occurs for it.

Output from a Curved Characteristic

Curvature of the rectifying characteristic modifies the resultant current components. Assuming the same initial applied potential the output now becomes:

(1*a*) A direct current component which is *not* directly proportional to the unmodulated carrier peak voltage.

(2*a*) The carrier frequency plus an infinite series of odd or/and even harmonics of complex amplitude relationship.

(3*a*) The modulator frequency *plus a series of harmonics*.

The change in (1*a*)—(2*a*) is not important, but, clearly, the presence of harmonics of the wanted component in (3*a*) is detrimental since distortion is produced. Furthermore, the acoustic output is not directly proportional to the modulation depth as it is in the ideal case.

Modern Methods of Detection—The Diode

The nearest approach to the ideal rectifier is undoubtedly the diode valve, in that the characteristic relationship between applied positive anode voltage and resultant current is substantially linear. The process of rectification tends very closely to the ideal,

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* MS. accepted by the Editor, May, 1934.

but the main disadvantages may be enumerated as follows :—

(1) The diode, in absorbing energy, places an effective shunt resistance across the signal source. Since this source is invariably a tuned circuit a loss of selectivity is inevitable.

(2) The device has no inherent amplification.

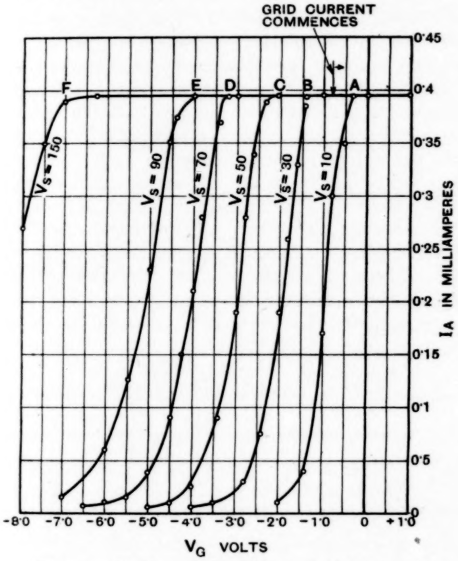

Fig. 2.—I_A/V_G. *Line voltage* = 205. *Load resistance* = 0.5 $n\ \frown$.

The Cumulative Grid Triode

In this case rectification occurs in the grid circuit, where one can regard the input system as a simple diode circuit. The acoustic voltage developed across the grid leak is amplified by the triode, so that the device possesses inherent amplification. The disadvantages are, in general, chiefly :—

(1) Resistance damping of the signal source.

(2) Presence of greater curvature, particularly to small signal amplitude.

(3) Limiting value to acoustic frequency response, due to time constant of coupling condenser and leak.

Anode Bend Triode or Tetrode

This method of rectification eliminates any resistance damping at the source, but in general possesses the following disadvantages :—

(1) Poor inherent amplification.

(2) Considerable curvature, particularly to small signal amplitudes.

It is desirable, therefore, to concentrate upon retaining certain features and eliminating others until ultimately the rectifier may possess the following qualifications :—

(1) A high degree of inherent amplification.

(2) Substantial linearity to both weak and strong signals.

(3) No resistance damping of the source.

The following rectification system possesses these qualifications and will now be discussed.

The Screened Grid Pentode as a Top Bend Rectifier

Fig. 2 represents a family of I_A/V_G curves taken with a resistive anode load of 0.5 megohm for different values of screen potential Vs.

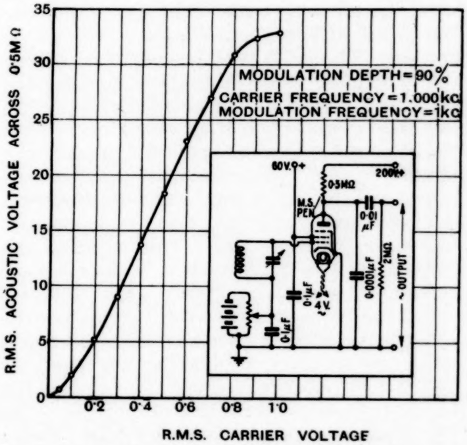

Fig. 3.—*V line* = 200 *volts*. *Vs* = 60 *volts*. V_G *bias* = − 3.0 *volts*.

The sharp curvature at the top bend is at once apparent and may be ascribed to the following process within the valve.

With the control grid at zero potential the electron current is controlled mainly by the screen and anode potential. Since the anode potential is approximately 5.0 volts and the screen greatly in excess of this, the electron velocity is mainly controlled by the screen which collects practically all the electrons.

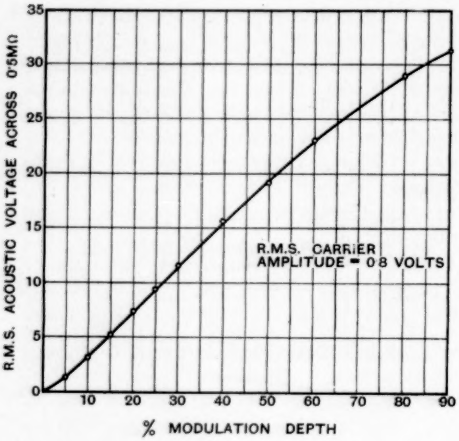

Fig. 3*a*.

Some, however, pass through the screen and come within the weak field of the anode. These are collected and represent the anode current. The passage of anode current drops the anode voltage, thereby limiting the collecting power of the anode. Hence, an increase of screen voltage while increasing the electron current does not assist the anode current, whose circuit load of 0.5 megohm converts it into a constant current device, particularly as the anode-cathode impedance is quite low. This explains the flatness of the curve over a wide range of screen volts.

As the bias is negatively increased the electron velocity is decreased until a critical value is reached beyond which there is insufficient electron velocity to enable the anode to collect but a small proportion of the initial value obtained with zero bias. Hence the anode current falls off rapidly.

As the screen voltage is increased greater electron velocity is produced. Hence, the negative bias must accordingly be increased to reach the critical point at which the anode current falls. This explains the shifting of the characteristic as a whole, with increasing screen volts.

The grid current characteristic is practically unaffected by these changes of screen potential and sets in at approximately — 0.8 volts, thereafter rising for any positive increment from this point. It can be seen, therefore, that part of the flat portion of the characteristic may be operated upon without entering into the grid current region, particularly at the higher screen voltages. It will also be seen that, while the operating slope decreases with increasing screen voltage, the input amplitude may be increased, the net result providing very little change in the maximum permissible voltage output. The screen voltage may therefore be adjusted to suit the general magnitude of the signal which it is desired to rectify. Screen voltages below 30 volts will not permit of operation over the whole characteristic without grid current flowing; but for small signal inputs a screen voltage of 30 and a negative bias of — 1.35 volts would produce excellent sensitivity.

It must be clearly borne in mind that the possibility of rectification is critically bound up with both grid bias and screen voltage, and adjustments for at least one of these values must be provided.

It would be necessary for some preset adjustment to be included in a set containing this system of detection in order to compensate for valve changes and to control other inevitable circuit variations.

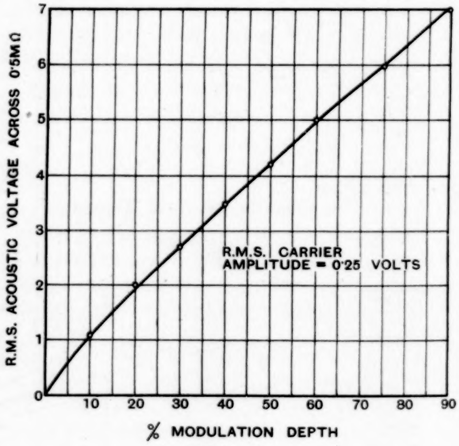

Fig. 3*b*.

Results and Circuits

The curves in Figs. 3, 3*a*, and 3*b* are self-explanatory together with the circuit by which they were obtained. It is at once evident that an excellent approach to linearity is maintained for the relationship between input and output for constant modulation, and, more important, between output and modulation depth for a steady input carrier voltage.

Automatic biasing

Normal automatic biasing by means of a cathode resistance is impossible in this system of rectification, and the reason for this is quite clear. The steady anode current is changed, due to the rectification effect, thus altering the bias voltage. Since this value is critical no further explanation is necessary as to the effect produced. Automatic bias may, however, be satisfactorily obtained by using the circuit of Fig. 4, which represents a practical method of including the system in a mains receiver.

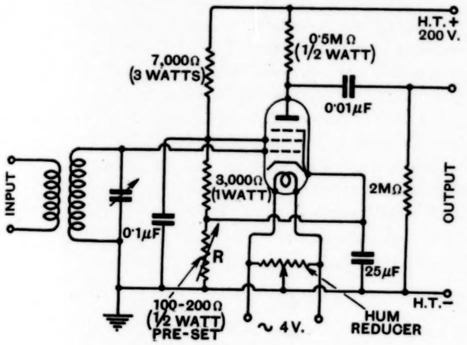

Fig. 4.

Here the bias is mainly controlled by the potentiometer current, which is in considerable excess of the anode current. Variations of the anode current due to the rectification process therefore exercise a negligible effect upon the bias voltage developed across *R*, which is of preset design and is adjusted for maximum sensitivity.

It may be of general interest to mention that another method of using this type of valve as a detector is known and used in some commercial receivers. In this case the screen voltage is applied via a resistance from the high-tension line, the value being of the order of 2 to 6 megohms and automatic bias is provided by normal cathode circuit dropping resistors. The principle differs entirely from the system discussed in that rectification occurs on the *lower* bend of the I_A/V_G characteristic, since the network is unstable to the critical conditions necessary for upper bend operation. Moreover there is a considerably less linearity and sensitivity, particularly to small signal inputs.

A notable feature, however, is the existence of a true limiting action which provides a high degree of self A.V.C. This is due to the rectifying action of the screen circuit, whereby the d.c. increments of screen current change the screen potential and set up new operating conditions for the rectifying anode circuit.

Symbolism in Electro-acoustics

By N. W. McLachlan, D.Sc.

THE question of symbolism in any branch of science is one over which numerous discussions have arisen. At the outset it may be fairly said that complete agreement is not to be expected, whilst it is out of the question to be strictly consistent. As far as possible suggestive symbols should be used, *e.g.* *V* for volume, *C* for capacity, *E* for electromotive force and *P* for power. In some cases, however, we hardly get as far as possible ! so it is necessary to give way to long established usage as in *I* for current. Although difficulties are met in electrical symbolism, they are eclipsed by those in electro-acoustics. Here one has to reconcile (1) electrical, (2) mechanical, (3) acoustical quantities and (4) mathematical functions. In 1932 when the author commenced the MS. of *Loudspeakers*,* no electro-acoustical symbolism was extant, so the problem had to be tackled. The work of the International Electrotechnical Commission is recognised as authoritative, so a list of their electrical symbols was obtained. Using this as a nucleus and with works by Rayleigh, Lamb, and others, for guidance, the list of symbols given in L.S. was evolved.

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* *Clarendon Press*, Oxford, 1934.

To differentiate succinctly between the four constituents mentioned above, a definite principle was needed. Examination of the I.E.C. list and of reference books, showed a tendency to use capital letters for electrical quantities. As the equations of electro-acoustics contain similar electrical, mechanical and acoustical quantities, *e.g.* resistance, some means of discrimination is essential. In this, one has to be guided not only by symbolism and usage in general, but by ease of visualisation. Take the case of impedance: it is desirable that the same letter of the alphabet be used in all three cases. If we accept this, there are various solutions to the problem. The italic capital Z is invariably used for electrical impedance, so we might write Z_e, Z_m and Z_a for electrical, mechanical and acoustical impedance, respectively. There are two objections, (1) the different subscripts and their main letters would not be easy to visualise distinctly in formulae, (2) it is desirable to have Z_m for motional impedance.* We might take a leaf out of our school-boy note-books when permutations and combinations were inflicted in the abstract upon unwilling scholars. The number of r-combinations of n letters is written ${}_nC_r$. It is not suggested that we write symbols on n pieces of paper and then draw lots! but we can use the back-handed subscript. Thus we might write ${}_mZ$ for electrical motional impedance in the pious hope that it will not be mistaken for m to the power Z. In electrical work we measure effective resistance and inductance, whilst in mechanical work we measure effective resistance and mass, thereby obtaining the mechanical impedance Z_m. Now $Z_m{}_mZ$ is a constant $\mathbf{C}^2$, and in a formula this symbolic representation might be difficult. As another example of symbolism the letters can be laterally inverted (Σ) † or we can put bars above or below (dots being ruled out since they have priority in mathematical analysis, *e.g.* $\dot{\xi}$, $\ddot{\xi}$ for velocity and acceleration), or they may have horizontal strokes through them. None of these methods is good, the symbols are difficult to visualise, and one might as well use Chinese. Nevertheless they were all tried in analysis and found wanting, so something simple and systematic was substituted. Accordingly capitals were used (as far as possible) for electrical, and small letters for mechanical and acoustical quantities, the latter bearing the subscript a *e.g.* z_a the acoustical impedance. No attempt was made to displace κ (dielectric coefficient), μ (permeability), ρ (resistivity) from their time honoured positions, although it would have been convenient to do so. There are other exceptions, *e.g.* power, but as this is translated from electrical to mechanical form, the symbol P is adequate, although P_e, P_m and P_a can be used.

As an example of the above, we reproduce the differential equations of the M.C. system, and the formula for electrical impedance derived therefrom (L.S., pp. 131, 132):

$$m_e D^2\xi + r_e D\xi + s\xi = \mathbf{C}I \qquad \ldots \qquad \ldots \quad (1)$$

$$LDI + RI + \mathbf{C}D\xi = E \qquad \ldots \qquad \ldots \quad (2)$$

$$Z = R + i\omega L + \mathbf{C}^2\left[\frac{r_e}{z_e{}^2} - \frac{i(\omega m_e - s/\omega)}{z_e{}^2}\right] \quad (3)$$

where m_e = effective mass, r_e = effective resistance, z_e = effective mechanical impedance, s = stiffness, ξ = axial amplitude, $\mathbf{C}^2 = z_e Z_m$, Z_m = electrical motional impedence, $D = d/dt$, $i = \sqrt{-1}$ and instantaneous values of cyclically varying quantities are implied (see below). The mechanical and electrical qualities in (1), (2), (3) can be visualised at once. In (3) the additional electrical resistance and inductance due to motion of the mechanical parts is very clear.

Sometimes it may be essential to discriminate between instantaneous, r.m.s. and peak values. Quoting from L.S. p. viii, "Throughout the text the r.m.s. values of all quantities varying cyclically are used, *unless otherwise stated or implied*. In differential or circuital equations the implication of instantaneous values will be readily discerned. . ." On the average this can be accepted, but where distinction is required, we have $I_{\text{ins.}}$, or $I_{\text{max.}}$ Cos ωt for sine wave motion, $I_{\text{r.m.s.}}$ and $I_{\text{max.}}$ or $\hat{I}$. It will be observed that the use of I for current leaves i for $\sqrt{-1}$, and as this conforms with mathematical usage, which has prior claim, it is preferable to use it. There is, of course, no objection to j.

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* Electrical motional impedance, as the term is not used in the mechanical sense.

† These might provide an excuse for carrying pocket mirrors!

We now come to symbolism for mass, reactance, resistance and impedance per unit area. It is desirable to retain the usual letters, so we now introduce heavy type. Thus for a rigid disk the resistance and reactance components per unit area are $\mathbf{r}_e$ and $\mathbf{x}_e = \omega\mathbf{m}_e$.[*] In MS. it is convenient to use a different coloured ink to assist the compositor. Concerning the term *rigid disk,* it often happens that it is misnamed a "piston." A piston is not a disk, because it is hollow and the head is not flat, and it would not move as a whole at all frequencies. A "rigid disk" states precisely what is meant, and is in conformity with the work and ideas of the late Lord Rayleigh. In the past the letter A has often been used for the strength of a sound source. It is preferable to use A for area as in $A = A_0 e^{\beta x}$, and $\mathbf{S}$ for the strength of a source (r.m.s.) since it is suggestive. The letter S is used for magnectic reluctance by the I.E.C., so in *Loudspeakers* heavy type was used to signify the strength of the source. To be consistent, it is perhaps better to use $\mathbf{s}$ for strength and $\mathbf{c}$ for condensation,[†] provided the former is not required for stiffness per unit area. Sound pressure has a few troublesome side issues. We should have $\mathbf{p}$, since pressure is taken on unit area. But we have to discriminate between total and excess pressure in a sound wave, acoustical and inertia (or inertial) pressure on a surface. Hence we have to be a bit elastic, so we get $p =$ excess, $p_o =$ atmospheric, $\mathbf{p} = p + p_o$, $p_a =$ acoustical, $p_i =$ inertial pressure.

The unit of pressure is one dyne cm^{-2}. In America this is one bar, but to a meteorologist it is a microbar. Although the latter has prior claim, it is preferable to talk of dyne cm^{-2}, not bars, because these are places *in* which one talks! Hitherto no units have been chosen for acoustical and mechanical resistance. Some honour to the G.O.M. of acoustics (the late Lord Rayleigh) is long overdue. If we take the first syllable of his name we have "Ray," which phonetically suggests R.A. (resistance-acoustical), and if we take "Ram" it suggests R.M. (resistance-mechanical). It is proposed, therefore, that "Ray" be taken as the unit of acoustical impedance and "Ram" as that of mechanical impedance, just as the Farad is the unit of capacity. The impedance per unit area would be Ray cm^2 if acoustical, and Ram cm^{-2} if mechanical. It will be observed that the ratio of these units is cm^4. This is due to the fact that the acoustical impedance of, say, a long uniform tube, is inversely proportional to the area, while the mechanical impedance offered to a disk vibrating at the end of the tube is directly proportional to the area.

Concerning definitions, a number of additional ones appear in L.S., pp. 3–6 (see amongst Nos. 20–44). In defining such things as sound flux, it is important to specify the air particle velocity *v normal* to an imaginary surface in the path of the wave. Also it should not be confined to equal velocity over the surface. Thus we have $\boldsymbol{\Phi} = \iint v dA$, and when v is constant over the area, $\boldsymbol{\Phi} = vA$. There is a very undesirable term used in electromechanical measurements, namely, "blocked" impedance. In L.S., pp. 269–271, a good reason is given why a telephone mechanism cannot be properly "blocked." The correct term, which says precisely what is intended, is "stationary," and in the author's experience this condition can only be obtained satisfactorily by using molten paraffin wax to make a solid job. We invariably speak of electrostatic L.S. but as this implies absence of motion, the correct terminology is Condenser L.S.[‡]

The question of the datum of intensity level should be settled. The A.S.A. has now adopted 2×10^{-4} dyne cm^{-2}.

In conclusion it may be stated that the above symbolism is easy to handle, and has found favour with a number of persons. It is not claimed to be ideal, but it has practical advantages.

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[*] In L.S., p. xi, lines 26, 27, mass and accession to inertia per unit area should be $\mathbf{m}$ and $\mathbf{m}_i$, not ρ_1 and ρ_i. For "effective" values (not r.m.s.) the subscript e is used, but in certain cases it can be implied, although it is sometimes necessary to reserve $\mathbf{m}$ for natural mass per unit area.

[†] In L.S., $\mathbf{s}$ is used for condensation.

[‡] In loudspeakers both of the terms electrostatic and condenser are used, but the latter is preferable.

Abstracts and References

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PROPAGATION OF WAVES

PRINZIP UND ANWENDUNG EINER DIAGNOSTISCHEN ANALYSE GEMESSENER SENDERFELDER (The Principle and Application of a Diagnostic Analysis of the Measured Field Strengths of a Station [in Mountainous Country, particularly when cut into by Fiords, etc.]). —O. Devik. (*Hochf:tech. u. Elek:akus.*, June, 1934, Vol. 43, No. 6, pp. 205–208.)

" In pronouncedly mountainous country the field of a broadcasting station is influenced to a high degree by the configuration of the land, and this is still more the case in those parts of a mountainous country where the sea cuts into the mountain range to form fiords, as on the Norwegian coast. In terrain of this kind it is of very little use to calculate field strengths by one of the usual formulae. In such cases it is only possible to get a quantitative estimate of the field strengths by a diagnostic analysis of the components of the measured field. Such an analysis is the object of the method here described, which should also find application in other forms of the field problem. The principle of the diagnostic analysis is the determination of the scalar field of the relative alteration of field strengths with respect to the ray direction, *i.e.*, the distribution of the quantity $1/E \,.\, dE/dr$ in the field radiated by a station. The ray direction is presumed to be known; in practice we may with sufficient accuracy assume that the projection of this direction on the horizontal plane will coincide with the straight line joining the point in question with the station. The effect of the earth's curvature is for the present neglected, since we are particularly interested in the direct radiated field, where very great distances are not involved.

" The horizontal radiation diagram of the station may be of any shape. The derived result applies also to directive transmitters, since no assumptions are made as to the field-strength distribution. It is only assumed that a sufficient number of measuring points are available for the construction of a synoptic chart (Fig. 1) with lines of equal field strengths. The change of field strength from the value E to $E + dE$, in passing over the interval dr from point (1) to point (2), is in part a geometrical effect due to the increasing of the field space or plane. According to Sommerfeld's representation of the field, the field strength from a pure space wave would be proportional to $1/r$ and from a pure surface wave would be proportional to $1/r^{0.5}$, for such distances that the earth's curvature has no influence. We shall return later to the question of the exponent, and for the present make the field strength proportional to $1/r^{a}$. Then the *geometrically* conditioned relative change of field strength is given by $1/E \,.\, (dE/dr)_{\text{geom.}} = -\, a/r$. In addition, the change of field strength depends on the *physical* conditions of the field space, the nature of the earth below and the Heaviside layer above. We put $1/E \,.\, (dE/dr)_{\text{phys.}} = -\,\alpha$, and call α the *dispersion constant* [zerstreuungskonstante] of the field strength. The total relative field-strength change in moving over the interval dr is thus given by $1/E \,.\, (dE/dr) = -\,\alpha - a/r \;.\;.\;.\;.\; (3)$, so that the diagnostically most important quantity, the dispersion constant, is given by

$$\alpha = -\,1/E \,.\, dE/dr - a/r \;.\;.\;.\;.\; (4).$$

In regions where the field strength decreases, in the direction of radiation, *more* than would correspond to the geometrical divergence, α is positive; where it decreases *less*, or even increases, α is negative. When, in the first case, where α is positive, pure absorption is predominant, α becomes identical with the absorption or attenuation constant, but the more comprehensive term ' dispersion constant ' corresponds better to the actual conditions."

If dE and dr are replaced by the finite small differences ΔE and Δr, which can be read off the synoptic chart at the receiving point in question, equation 4 gives the value of the dispersion constant at that point. In this way the dispersion constants for a sufficient number of points could be calculated and from these values a corresponding synoptic chart of the constant could be drawn. It is however more convenient and also more accurate to derive from the synoptic field-strength chart (Fig. 2a) separate synoptic charts of $-\,a/r$ and $-\,1/E \,.\, dE/dr$ (Figs. 2b and c) and then by graphical addition of these to obtain the synoptic chart of α (Fig. 2d); for the quantity a/r is widely independent of the existing field and a value can be assigned to a (in Fig. 2b it is taken as 0.5), so that the synoptic chart of a/r becomes a series of concentric circles round the station. The graduations of the two charts should be so chosen that their graphical addition is straightforward.

The writer derives from equation 3 the exponential equations 6 and 7 showing that the field strength as a function of the distance r from the station is represented, over a short interval, by an exponential curve. If α_m represents the mean value of the dispersion constant over the stretch $r_1 - r_0$, equation 7 is $E_1/E_0 = (r_0/r_1)^a \cdot e^{-\alpha_m(r_1 - r_0)}$. This agrees with the Austin and Watson/Eckersley formulae if a is put equal to 1 and 0.5 and $\alpha_m = \alpha'/\sqrt{\lambda}$, and if the effect of the earth's curvature is neglected. By the application of equation 6 or 7 to a particular direction of radiation the field strength at any point of the ray is obtained provided the initial field strength at the distance r_0 is known: this can be calculated from the power of the station. If in this way the field-strength distribution is found for a sufficient number of directions, the synoptic chart of field strengths can be drawn.

In section 4 the writer deals with the effect of the earth's curvature. Section 5 is a discussion of the whole problem, which is compared to a meteorological one and then to an optical one. The effect of the indirect ray is then considered: like the direct ray, this must suffer greater dispersion in mountainous country than in flat, owing to the irregular reflection in its hops between earth and Heaviside layer. The partial interdependence of a and α is discussed. "With very small values of absorption the surface ray will become more and more prominent as the distance increases, so that the value of a will approach 0.5, while with larger absorption and predominating space wave the value 1 better represents the conditions. It is to be expected that a study of synoptic chart material of the quantity $-1/E \cdot dE/dr$ (which by equation 4 is equal to $\alpha + a/r$) will give empirical rules for the correct proportioning of this quantity." Finally the point is discussed whether α can be correctly subdivided into $\alpha_1 + \alpha_2 + \alpha_3$, corresponding to absorption effects depending almost entirely on the wavelength; to effects depending on the influence of the topography (shadow effects of mountains, and the like; also dependent on the wavelength); and to indirect ray effects.

Comparison of the Sommerfeld/van der Pol and Watson/Eckersley Propagation Formulae as applied to Ship Stations at Distances of 400–500 Kilometres.—Marique. (*See* abstract under "Aerials and Aerial Systems.")

Reflection of Ship Waves from Dover Cliffs.—Marique. (*Ibid.*)

Mitteilung über die Bergradioversuche in Kotterbach (Report on the Kotterbach Radio Tests in Mines [Strength of Received Signals from Broadcasting Stations and Portable Oscillators]).—V. Fritsch. (*Hochf: tech. u. Elek:akus.*, June, 1934, Vol. 43, No. 6, pp. 189-195.)

For the writer's previous work on the same lines *see* 1933 Abstracts, p. 558. In the present tests the region investigated was geologically inhomogeneous, in contrast to the tunnels and caves in the homogeneous mountain side previously examined: it consisted of mine workings in a gangue of spathic iron ore. The results of the tests described in this paper (which is a first report) are summarised as follows:—(1) Broadcast stations (medium- and long-wave) could be received at levels down to 300 metres. (2) The strength of signal increased with the wavelength; waves below 400 m could not be heard. (3) The tectonic construction has a great influence on the propagation inside a mine. (4) The smallest attenuation is suffered by a field entering along a fissure; the water-bearing property of this is of great importance. (5) The total conductivity of an ore-bearing vein depends not only on the conductivity of the gangue composing it but also on that of the pore- and fissure-water. The conductivity of this water increases with the solution concentration. (6) The attenuation of a field radiated-in in the direction of the slope of the clay coat of the veins is less than that of one entering in the direction of the bearing of the vein. (7) The attenuation suffered by a field radiated along a lode depends very much on the nature of the outcrop of the lode. (8) The absorption effects observed lead to the conjecture that there is a further lode to the south of the Drozdiak vein.

Wireless Echoes from Regions above the F Layers.—H. R. Mimno. (*Nature*, 14th July, 1934, Vol. 134, pp. 63–64.)

The writer and his co-workers have recently obtained a large number of fixed-frequency continuous automatic records of effective ionospheric heights (Abstracts, 1933, p. 386: *see* also pp. 438 and 439, and May, p. 260). Records obtained at the frequency of 3 492.5 kc/s frequently give first-order echoes which appear to come from regions of considerably greater effective height than the F layer. The writer feels "reasonably certain that the effects were not due to the low group velocities ordinarily encountered in the E and F regions when the electron density is near a critical value." He has obtained "a series of consistent records which apparently rule out this explanation." He classifies the experimental results into "G reflections" (effective height approx. 600 km) and "H reflections" (effective height 1 100 to 1 800 km); it is not yet known whether the new regions are directly overhead or not.

Ionosphere Measurements at Low Latitudes [F_2 Critical Frequency several Thousand Kilocycles higher in Peru than at Washington: Diurnal Variation much more Erratic than that for Lower Layers].—L. V. Berkner and H. W. Wells. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, p. 680: short summary only.)

Some Recent Work on the Ionosphere in Canada [to August, 1933: Anomalous Cases of Echoes from Region F when Region E was much more intensely Ionised than Region F].—J. T. Henderson: Ross. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 679–680: short abstract only.)

Heights and Train-Drifts of Leonid Meteors of 1932.—C. P. Olivier. (*Physik. Ber.*, 1st June, 1934, Vol. 15, No. 11, p. 912.)

Comparison of the Continuous Spectra of Certain Stars of Types A and B: Night Estimates of Atmospheric Ozone Content.—Barbier, Chalonge and Vassy. (*Comptes Rendus*, 18th June, 1934, Vol. 198, No. 25, pp. 2139–2142.)

The Refractive Indices of Some Liquids in the Domain of the Short Electric Waves [Micro-Waves].—M. Miesowicz. (*Nature*, 28th July, 1934, Vol. 134, p. 155: abstract of paper in *Polish Acad. of Sci. and Letters*.)

"The wavelengths employed were 7.1 cm and 6.2 cm, an interference method being used. In all the liquids examined except water, the same value was obtained as with very long waves; water, with the shortest wave, gave a slightly higher value."

Die Dispersion und Absorption elektrischer Wellen (Dispersion and Absorption of Electric Waves [Summarising Account of Theories and Measurements of Dielectric Constant, Its Dependence on Frequency in Various Liquids: Evidence for Debye's Theory of Dipole Orientation, including Radio Frequencies]).—W. Ziegler. (*Physik. Zeitschr.*, 15th June, 1934, Vol. 35, No. 12, pp. 476–503.)

Riflessione e Rifrazione della Onde elettromagnetiche armoniche di Forma qualsivoglia ad una Superficie piana (The Reflection and Refraction of the Harmonic Electromagnetic Wave of any Form whatever at a Plane Surface).—G. A. Maggi. (*Physik. Ber.*, 1st June, 1934, Vol. 15, No. 11, p. 886.)

The writer has already found (*Rendiconti dell' Instituto lombardo, Milan*, No. 9, Vol. 18, 1933, pp. 335–341) that the general theory of the electromagnetic field does not lead to single-valued solutions for the reflected and refracted waves of arbitrary form in isotropic, non-conducting neutral media separated by a plane surface. "In the present investigation the writer gives the conditions under which a satisfactory solution of the problem is possible."

Correnti nei Conduttori ed Onde associate (Currents in Conductors and the Associated Waves).—G. Peretti. (*Physik. Ber.*, 15th June, 1934, Vol. 15, No. 12, p. 967.)

"According to Hugoniot and Hadamard it is mathematically possible to link the electromagnetic wave propagation along lines with certain other phenomena, so far as these are represented by space-time functions of points, which are connected by a system of differential equations. On the basis of their theory the writer investigates the wave propagation in connection with electromagnetic phenomena in a system of straight parallel conductors."

Der Scheinwiderstand am Eingang von Hochfrequenzkabeln (The Impedance at the Input End of High-Frequency Cables).—W. Kautter. (*Funktech. Monatshefte*, June, 1934, No. 6, pp. 217–219.)

Laue Diagrams with Optical Waves [passing through Space Lattice produced in Liquid by Sound Waves from Piezo-Quartz Crystals].—C. Schaefer and L. Bergmann. (*Sitzungsber der preuss. Akad. der Wiss., physik.-math. Kl.*, 1934, No. 10, pp. 152–153.)

The Diffusion of Light by Binary Mixtures near the Critical Point of Complete Miscibility: Measurements of the Depolarisation Factor.—A. Rousset. (*Comptes Rendus*, 18th June, 1934, Vol. 198, No. 25, pp. 2152–2154.)

The Propagation of Light through Sea Water [Summary of Survey in *Scientia*].—Vercelli. (*La Ricerca Scient.*, 15/31 May, 1934, 5th Year, Vol. 1, No. 9/10, pp. 543–544.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

The Radiations from the Night Sky in the Spectral Band 5 000/8 000 Å [and the Identity of the Spectrum with that of Polar Auroras: etc.].—J. Cabannes. (*Comptes Rendus*, 18th June, 1934, Vol. 198, No. 25, pp. 2132–2135.)

On Atmospheric Radio-Activity and Peiping Weather.—K. C. Wang. (*Sci. Rep. Nat. Tsing Hua Univ.*, October, 1931, Vol. 1, No. 3, pp. 119–128: in English.)

Protection against Surges—Lightning Arresters and Surge Absorbers.—E. T. Norris. (*Electrician*, 8th June, 1934, Vol. 112, No. 23, p. 785–786.)

The Behaviour of the Aluminium Cell [Lightning Arrester] against the Travelling Waves.—T. Tomizuka. (*Journ. I.E.E. Japan*, April, 1934, Vol. 54 [No. 4], No. 549, pp. 257–260: English summary pp. 34–35.)

Ionisation at High Pressures [as in Cosmic Ray Measurements: "Apparent" Saturation for High Voltages explained quantitatively by Columnar Ionisation].—G. Harig. (*Physik. Zeitschr. der Sowietunion*, No. 4, Vol. 5, 1934, pp. 637–640: in English.)

On the Radiation producing the "Showers" [New Triple Coincidence Measurements].—G. Bernardini. (*La Ricerca Scient.*, 15/31 May, 1934, 5th Year, Vol. 1, No. 9/10, pp. 533–536.)

Auroras and Cosmic Rays—Observations of the French Expedition at Scoresby Sound.—A. Dauvillier. (*Electrician*, 8th June, 1934, Vol. 112, No. 23, pp. 787–789.) Abridged translation of the paper dealt with in June Abstracts, p. 317.

The Azimuthal Effect of Cosmic Rays [Neutrality of Space gives Equal Numbers of Positive and Negative Ions traversing Space with Identical Velocities, which are separated by Earth's Magnetic Field].—R. Gunn. (*Phys. Review*, 15th June, 1934, Series 2, Vol. 45, No. 12, pp. 900–901.)

Critical Remarks on a Paper by G. Lemaitre and M. S. Vallarta on Cosmic Radiation.—C. Störmer. (*Phys. Review*, 1st June, 1934, Series 2, Vol. 45, No. 11, pp. 835–838.)

For reference to the paper in question *see* 1933 Abstracts, p. 209. The present preliminary remarks give a detailed criticism of this paper and the conclusion is reached "that the numerical results on the intensity distribution of cosmic radiation given by Lemaitre and Vallarta must be illusory."

The Analysis of the Cosmic-Ray Absorption Curve [Theory of Absorption Curves, using Laguerre Functions: No Evidence for Line Structure of Spectrum].—C. Eckart. (*Phys. Review*, 15th June, 1934, Series 2, Vol. 45, No. 12, pp. 851–859.)

PROPERTIES OF CIRCUITS

Graphische Behandlung von Mitnahmeerscheinungen (The Graphical Treatment of "Mitnahme" [Pull-In] Phenomena).—U. Bab. (*E.N.T.*, May, 1934, Vol. 11, No. 5, pp. 187–194.)

Pure analytical treatments of the mitnahme effect have led to results which differ considerably from the experimental observations. This is largely due to the fact that the various non-linearities existing in every self-oscillating system have to be taken into account, so that complex differential equations of high orders are arrived at whose solution, by approximations often only very rough, is only possible within certain limits and with great labour. It is, moreover, difficult to obtain from the analytical results any clear picture of the physical interactions producing the phenomena. The writer has therefore evolved a graphical method of investigating the influence of external frequencies on the frequencies of self-oscillating systems. The basis of this method is that the simplified vector diagram of the self-oscillating circuit (Fig. 4, derived from the complete vector diagram of Fig. 3) is suitably combined with the Möller "oscillating characteristic."

After dealing with the comparatively simple case of mitnahme by an unmodulated incoming carrier wave, the writer applies his method to "side-band mitnahme," in which a self-excited modulated oscillator is so affected by an incoming carrier wave that one of the oscillator side-bands, and not its carrier frequency, is pulled-in to the incoming frequency; as a result of this the carrier wave, and also the other side-band, is similarly displaced. Thus in Fig. 10 an oscillator frequency ω_r modulated with a frequency ω_m is so affected by an incoming frequency ω_f (close to the side-band $\omega_r + \omega_m$) that all three oscillator frequencies are displaced into the positions shown by the dotted lines.

The circumstances are represented diagrammatically by Fig. 11, where the grid of the regenerative triode is subject to $\mathfrak{E}_u$, the regenerating frequency; $\mathfrak{E}_m$, the modulating frequency; and $\mathfrak{E}_f$, the incoming frequency. The modulating frequency produces a swinging to-and-fro of the Möller characteristic, as shown in Fig. 12. This is embodied in the mitnahme diagrams of Fig. 13. Since the incoming frequency is, by assumption, near a side-band, it can never be the same as the carrier: the incoming vector must always have a certain speed of rotation with regard to the rest of the diagram. Further, the carrier is subjected to an amplitude fluctuation due to the modulation, while in addition an amplitude fluctuation will occur as a result of beating between carrier wave and incoming wave. In the neighbourhood of side-band mitnahme the modulation and the beat action have almost or exactly the same frequency. The four diagrams of Fig. 13 represent four different phase relations between modulation and beat action, shown in the vignette at the top left-hand corner of each diagram: each diagram corresponds to one complete revolution of the incoming vector $\mathfrak{E}_f$. In diagram II, where modulation and beat action are co-phasal, the fluctuation of the grid potential $\mathfrak{E}_g$ (*see* Fig. 11) is at its maximum; in diagram IV, where the two are in opposed phase, its fluctuation is very small. In both these diagrams the oscillator frequency swings symmetrically to either side: that is, it remains on the average unchanged during a beat period. In diagrams I and III the swings are asymmetrical, so that the oscillator frequency is on the average decreased during a beat period in diagram I and increased in diagram III. Within this interval between these minimum and maximum average frequencies, side-band mitnahme can occur, provided the incoming frequency is separated from a value lying between these two frequencies by the amount of the modulation frequency.

On the Theory of Electric Filters [Properties expressed as Continuous Fractions].—V. Bubenik. (*Rev. Gén. de l'Élec.*, 30th June, 1934, Vol. 35, No. 26, pp. 875–877.)

Remark on the Above Method of Calculation [Equivalent Classical Method with Hyperbolic Functions preferable in Practice].—L. Abélès. (*Ibid.*, pp. 877–878.)

Harmonic Production and Cross Modulation in Thermionic Valves with Resistive Loads [Mathematical Analysis, with Example of Great Distortion of a Small Signal by a Large One of Different Frequency, in an Output Pentode].—D. C. Espley. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 781–790.)

Resistance Tuning.—Cabot. (*See* under "Reception.")

TRANSMISSION

Experimentelle Untersuchungen über Elektronenschwingungen (Experimental Investigations on Electron Oscillations [of Ultra-High Frequency, in a Low-Voltage Circuit consisting of an Inductance and a Condenser with a Cathode between its Plates]).—J. Müller. (*Hochf:tech. u. Elek:akus.*, June, 1934, Vol. 43, No. 6, pp. 195–199.)

The mathematical basis of this method of generating electronic oscillations in a high vacuum was given in a previous paper (1933 Abstracts, pp. 443–444). The theoretical predictions are now qualitatively confirmed by the experiments described: quantitative confirmation was upset by a strong evaporation of the barium oxide of the cathode. The cathode base consists of a thin square box made of 0.55 mm nickel sheet, with one narrow side-wall left open: the other two narrow walls are riveted. The heater consists of tungsten wire spirals wound on four parallel steatite rods, held one below the other in two nickel strips, each perforated with 4 holes into which the ends of the rods fit. The four spirals are so wound and connected as to neutralise the outward magnetic field. The whole heater is pushed into the cathode box through the open narrow side, which is then closed by a U-shaped nickel strip held in position by bending over two lugs on the cathode box: one end of the winding is connected to the box. The whole cathode is suspended by a steatite tube with a thin nickel-foil sheath which carries the anode current and acts as one heater lead, the other being a nickel wire led out through the steatite tube. This construction gives a mechanically stable support for the cathode, a low thermal conductivity, and complete electrostatic screening of the inner heating lead. The oxide coating is deposited on the two square sides of the box, by the paste process. An alternative, round type of cathode consists of a piece of nickel tube of 4.5 cm diameter, with its two ends closed by round oxide-coated discs. The whole oscillatory circuit is enclosed in a high-vacuum container; the brass base of this, and both the heating leads, are water-cooled. The brass base supports the two standards which carry the two plates of the condenser and which form (with the intervening base) the inductance of the oscillatory circuit. Different lengths of standard can be used so as to vary the inductance: the condenser gap can also be adjusted. The cathode suspension tube is hung from the top end of a bent hollow standard carrying the cooling water, so that the flat cathode lies centrally between the condenser plates. A three-stage mercury diffusion pump is used to obtain the high vacuum. A heat guard, in the form of a copper can, is inverted over the whole oscillatory circuit and rests on the brass base.

Owing to the presence of this can, the circuit is completely screened as regards high frequencies, but the oscillations can be shown by the change in anode current and also by the emergence of a certain amount of high frequency along the heating leads, as a result of imperfect circuit symmetry. By means of a Lecher pair, outside the container and connected to these leads, the wavelengths can be measured. The stopping of the oscillations is accomplished at will by a piece of wire (B_2 in Fig. 3) in the central vertical pump connection through the base: after entering some way into the container this wire bends horizontally, so that when its lower end is twisted the horizontal part turns and touches one oscillatory-circuit standard. The twisting is done by means of a magnet, outside the pump connection, acting on an armature fixed to the bottom end of the wire.

The following results were obtained. (1) The frequency is chiefly determined by the oscillatory circuit. (2) There is a slight decrease of wavelength when the anode voltage is increased. (3) The oscillation zone lies in the region in which the equivalent resistance of the electron stream is negative. In the apparatus described the square and round cathodes had effective emitting surfaces of 50 and 32 cm^2 respectively, the gap between these surfaces and the anode plates being of the order of 0.45–0.7 cm; the anode voltages were of the order of 25–90 volts, and the cathode heating power ranged from 240–270 watts. The wavelengths obtained were around 1 metre. It is concluded that the anode current is completely controlled and that the anode efficiency amounts to about ½%.

In a special investigation into the properties of the special cathode it was found that the current/voltage characteristic, carefully taken (with anode current compensation), showed a certain faint ripple (Fig. 7): in connection with the examination of this, a modulation-note method for rapidly determining the second differential coefficient of the characteristic is described.

Über Röhrenwirkungsgrade und Frequenzmessungen im Ultrakurzwellengebiet (Valve Efficiencies and Frequency Measurements in the Ultra-Short-Wave Region [8.4 and 3.12 Metres: Tourmalin-Controlled Single-Valve Generator and Its Frequency Variation on Prolonged Working]).—R. Beck. (*Hochf:tech. u. Elek:akus.*, June, 1934, Vol. 43, No. 6, pp. 199–205.)

Mouromtseff and Noble found that the efficiency of a water-cooled high-power valve was 20% at 2.8 m and 43% at 5.5 m: Wenstrom found that loudspeaker valves in a self-excited single-valve circuit gave an efficiency of 32% and in a push-pull circuit 31.5%, for a wavelength of 3.12 m (Abstracts, 1932, pp. 636 and 163). "Since the knowledge of the efficiency of the tourmalin-controlled single-valve transmitter is also important, in the following work the attempt will be made to measure the efficiencies of this transmitter at 8.4 and 3.12 m and to compare them with the efficiencies of the self-excited transmitters. Among other things, certain practical questions arising from the working of tourmalin-controlled transmitters will be investigated for a wavelength of 8.4 m; for example, the heating-up of the tourmalin holder and the frequency variation on prolonged working."

In the 1–10 m band the external coupling is in general so small that oscillation will only set in if the characteristic has a very steep slope; the audion (leaky-grid) connection is therefore very desirable. It is shown here that the best efficiency, as well as the maximum r.f. output, depends very closely on the value of the grid leak, and can be brought to its optimum value by adjustment of the latter. In his measurement of efficiencies the writer uses H. M. Turner's thermometric method (*see* Wenstrom, *loc. cit.*) in which a thermoelectric couple is pressed against the valve bulb. Precautions had to be taken to avoid errors due to the intrusion of r.f. energy into the thermocouple and the galvanometer leads, and to keep the filament-current voltage constant. An accuracy within 2% was obtained. For his 8.4 m wave the writer used the Huth-Kühn circuit, for his 3.12 m wave the circuit (derived from a three-point connection) used by Wechsung: a wrong reference is given here—*see* Abstracts, 1928, p. 518, and 1930, pp. 394–395.

On the 8.4 m wave the efficiencies of the RE 134 and REN 904, both as tourmalin-controlled and as self-excited oscillators, are shown as functions of the d.c. input for different grid-leak values in Figs. 5 a–d. All the curves show that not only the generated r.f. power, but also the efficiency, increases with the d.c. input. They also show the marked dependence on the grid-leak value already mentioned. For this particular wavelength the optimum value is 4–5 000 ohms for the RE 134, and 2–3 000 ohms for the REN 904, both with and without the tourmalin control. The optimum efficiencies are tabulated in table 2. The corresponding optimum *overall* efficiencies (taking into account the power used in heating) are given in table 3. The highest overall efficiency is 33.1% for the tourmalin-controlled oscillator as compared with 41% for the self-excited oscillator (the author's summary seems to be incorrect here). On the 3.12 m wave the efficiencies are considerably smaller: the curves of Fig. 6 show this, for the same two valves and also for a Tekade type. The increase of efficiency with d.c. power is less marked than at the longer wavelength; this may be attributed to the under-voltaged condition of the transmitter. These curves were taken with the same external capacity ($C_A = 50$ cms) for all three valves. When the optimum L/C ratios in the anode circuit are found by trial, and the corresponding efficiencies are again measured, some of the results are considerably changed (table 4) and values of 33% can be obtained both with and without the tourmalin control: it is not clear whether these are overall efficiencies or not, the author's summary again appearing inconsistent with the text.

In section IV the writer describes measurements on the frequency constancy of the 8.4 m tourmalin-controlled transmitter, by a heterodyne method. The frequency variation occurring is chiefly due to the temperature changes of the tourmalin. Variations up to 30 000 c/s can be observed when the d.c. anode power is changed, the transmitter being allowed to run for some 16 minutes after each change in order to arrive at a stable frequency. This change of frequency with the load varies according to the grid leak; with a smaller leak the tourmalin becomes less heated, the a.c. potentials building-up at the crystal being smaller. Another factor in the production of frequency variation is lack of symmetry in the design of the tourmalin holder.

The Importance of the "Constant-Frequency Curves" in Micro-Wave Generation and Modulation.—Clavier. (*See* abstract under "Stations, Design and Operation.")

Note on an Ionised Gas Modulator for Short Radio Waves [Micro-Waves].—E. G. Linder and I. Wolff. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 791–793.)

Description of the method referred to in July Abstracts, p. 378. With a 10 cm wave, under practical conditions almost 100% modulation should be obtained by the use of a path length of 20 cm in the gas, with an accompanying change in index of refraction of 0.3 above and below that of the gas ionised by the d.c. current. This leads theoretically to a frequency modulation equal to $\pi \times$ modulating frequency, which is "not too severe for a great many purposes" and may prove still smaller if dispersion, refraction and reflection play an important part in increasing the modulation due simply to absorption, thus enabling the variation of the refractive index to be reduced. "The quality of the modulation . . . is equal to that obtained by more direct means. It is found that the adjustment of the oscillator, which for direct modulation may be somewhat critical or difficult to maintain, is quite easily maintained when no modulation is applied to it directly."

Frequenzstabilisierung von Röhrenoszillatoren mit Hilfe von Schirmgitterröhren (The Frequency Stabilisation of Valve Oscillators by the use of Screen-Grid Valves [Current Distribution in Valve kept constant in Phase and Magnitude by the Auxiliary Electrode]).—K. P. Schweimer and L. Pungs. (*Hochf:tech. u. Elek:akus.*, June, 1934, Vol. 43, No. 6, pp. 181–189.)

A method is described whereby, without crystal control, a frequency of 2×10^6 c/s is varied by only 20 c/s when the anode voltage fluctuates by 50% or the heating voltage by 20%.

Frequency stabilisation without the inconvenience of crystal control has already been dealt with by a large number of writers, but a satisfactory practical solution appears to be still lacking. The chief cause of frequency fluctuation is usually given as the changes in grid current, but in the theoretical analysis the grid current is not, in general, itself included, but is replaced by valve data related to it. The dependence of these data on the d.c. voltages is, however, very difficult to deal with satisfactorily and it seemed better to the present writers to include the grid current itself in the calculations. In section I, therefore, they derive on these lines the frequency equation (5) for a simple retroactively coupled oscillator. Since, in this equation, $\mathfrak{J}_r = \mathfrak{J}_a + \mathfrak{J}_g$ (where $\mathfrak{J}_r$ is the vectorial sum of all a.c. currents in the valve) the ratio $\mathfrak{J}_a/\mathfrak{J}_r$ can be replaced by $(1 - \mathfrak{J}_g/\mathfrak{J}_r)$; the equation then contains, as the only variable which can vary with the supply voltages and thus be responsible for the frequency variations, the complex current ratio $\mathfrak{J}_g/\mathfrak{J}_r$. Thus it is seen that for the frequency constancy of any type of circuit *it is only necessary that the complex current ratio in the valve, i.e. the current distribution in the valve, should remain constant in magnitude and phase even when the supply voltages vary.* It is not sufficient, as previous writers have thought, merely to regulate the phase, *e.g.* by introducing suitable impedances in the anode or grid circuit.

After a short discussion of the way in which, in single-grid self-excited valve circuits, the current distribution and its dependence on the supply voltages is regulated by the mutual dependence of grid and anode potentials and the design of the valve, and of the way in which an additional degree of freedom can be introduced by an auxiliary cold electrode such as a screen grid, the writers pass on to the experimental part B of the paper. Typical curves obtained are those of Fig. 4a and b, for a screen-grid valve. Curves a show the frequency variation as the anode d.c. voltage is varied, the screen-grid d.c. voltage being kept constant; curves b show the frequency variation for the converse case. Since the two pairs of curves are of approximately opposite character, the obvious step is to link the anode and screen-grid d.c. voltages in such a way that a frequency variation produced by a change in the one is countered by a corresponding change in the other. When this is done (by a potential-dividing connection, switch *S*, in Fig. 3, being set in position *B*) the variation of frequency with the common battery voltage is given by the curves shown in Fig. 4c, the three curves being for three different ratios of screen-grid voltage to anode voltage. For a suitable value of this ratio (in this case the intermediate value of 125/200) the frequency remains constant over a wide voltage range: the voltage can be halved without the frequency changing by more than 15 c/s for a fundamental frequency of about 1.5×10^6 c/s. The writers here refer briefly to the work of Dow (1932 Abstracts, p. 164: see also *ibid.*, p. 222).

In the next two sections it is shown that with screen-grid valves under certain conditions interactions are apt to occur between screen grid and anode, corresponding to those occurring in single-grid valves in the over-voltage condition, when, owing to a large increase of grid current, a dip is produced in the anode-current characteristic. It is found by experiment that with all the valves tested the screen-grid and anode voltage ratio which is best for frequency stabilisation is always such that the valve is working somewhere near the border-line between the over-voltage and under-voltage conditions, and generally rather more in the over-voltage region. Here is another advantage of the method, for in most stabilising methods it is desirable that the valve should be only feebly oscillating, while with the present arrangement the conditions best from the energy standpoint are also best for constancy of frequency. But section V of Part B shows that to maintain these optimum conditions, when a wide frequency range is required to be worked over, it is necessary to keep constant the anode-circuit resistance and the retroactive coupling; otherwise the voltage ratio would require changing at every alteration of working wavelength. This could be done by altering capacity and inductance in the closed oscillatory circuit simultaneously, so that L/CR remained constant: but the coupling would also have to be altered at the same time. The simplest plan is to alter only C to obtain the new wavelength, and then to adjust the series condenser C_a (Fig. 3) to re-establish the optimum constancy (adjustment of C_g would have a similar effect). The trend of adjustment is the same for C and C_a, so that by a suitable shaping of the plates it should be possible to mount the two condensers on the same axle.

Section VI of Part B deals with the effect of heating-voltage variation on the frequency. Indirectly heated valves are preferable for two reasons—avoidance of voltage-drop along the filament, and greater thermal inertia. The experimental curves show that for the best frequency constancy (as regards heating-voltage fluctuations) a strong heating is desirable. In the literature a low heating is generally recommended, owing to the exponential relation between heating and emission. This is only correct so long as saturation phenomena play a part in oscillation generation; but with modern barium-oxide cathodes saturation only becomes of appreciable effect outside the normal working conditions. The influence of heating fluctuations, with such valves, only becomes serious when the heating is very low.

Finally, it is pointed out that as regards heating fluctuations the best frequency constancy is obtained with a low voltage ratio, whereas as regards anode-voltage fluctuations there is a definite, medium ratio which is best (*see* above). Therefore a favourable compromise must be chosen for a particular case, the choice depending on whether the heating source or the anode-voltage source is the more likely to be subject to large fluctuations.

QUARTZ-CRYSTAL-CONTROLLED OSCILLATOR CIRCUITS [Frequency Drift due to Heating of Quartz much reduced by New Circuit decreasing Energy Dissipation: Consistent Stability of better than 10 Parts in 10^6 in Broadcasting Station WGY].—H. R. Meahl. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 732–737.)

One factor in reducing the energy dissipation is that the presence of the tuned grid circuit in series with the crystal makes it possible to have the usual grid/filament voltage-swing on the oscillator valve but with only part of it across the crystal.

ÜBER DIE SCHWEBUNGEN DER GLEICHWELLENSENDER (The Beating of Common-Wave Transmitters).—P. R. Arendt: Lorenz Company. (*E.N.T.*, June, 1934, Vol. 11, No. 6, pp. 201–209.)

Supplementary to the writer's paper published elsewhere (July Abstracts, pp. 378–379). It is shown that the phase rotations liable to occur in the linking cable, as used in the Lorenz Company's system, have no ill effects on the exactness of the carrier wave provided that at the controlled stations the subsidiary tuning forks are present to act as filters, with a suitably chosen compromise between short building-up time (for greatest accuracy of synchronisation) and sharp resonance (for greatest freedom from interference). Only the most unfavourable conditions of rapidly occurring rotations lasting over a long time could have a serious effect, and these have not been found to occur: in this connection the writer makes use of the phase measurements (in less favourable conditions, the cable being 750 km long instead of the 200 km of common-wave transmission) made by Pohontsch. The obtainable frequency agreement can be calculated from the frequency curve of the main tuning fork and the building-up times of the subsidiary forks.

THE KALLIROTRON AS A CONSTANT-FREQUENCY OSCILLATOR.—R. Usui. (*Journ. I.E.E. Japan*, April, 1934, Vol. 54 [No. 4], No. 549, p. 298: letter, in Japanese.)

ON THE PROBLEMS OF REGENERATION, PUSH-PULL OPERATION, MODULATION AND SECONDARY COUPLED CIRCUIT OF THE DYNATRON OSCILLATOR.—T. Hayasi. (*Journ. I.E.E. Japan*, April, 1934, Vol. 54 [No. 4], No. 549, pp. 260–268: English summary p. 35.)

"Colebrook's dynatron oscillator [1932 Abstracts, p. 34] is unsuitable to the tetrode, for which the positive inner-grid potential is required. To overcome this difficulty, a low-resistance choke coil of sufficient reactance is used instead of the high resistance in the inner-grid circuit. By this substitution, the dynamic negative resistance can be decreased by half in magnitude, and the oscillatory current can be increased." The effects of coupling between anode and inner grid, and between anode and outer grid, are considered. The latter, unlike the former, does not bring about any special advantage as regards intensity of oscillation. The "oscillationless" region, often found in a retroactive oscillator, may be assumed to be a case of coupled-circuit phenomena having the outer-grid circuit for the secondary. The push-pull dynatron oscillator, more stable than the single-valve type, is investigated: the experiments show the important effect of the anode d.c. on the oscillating states of both valves. Constant current, constant voltage, and absorption methods of modulation are discussed, and coupled-circuit experiments which showed the occurrence of the normal regenerative-oscillator phenomena of "ziehen" (oscillation hysteresis), oscillationless coupling, and imaginary coupling: the "Watanabe diagram" (1929 Abstracts, p. 506) can therefore be drawn, of shape similar to that of the normal oscillator.

THE INNER-GRID DYNATRON AND THE DUODYNATRON [using Secondary Emission from Inner Grid of Tetrode: Duodynatron giving Simple One-Valve Beat-Frequency Oscillator].—T. Hayasi. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 751–770.) *See* 1933 Abstracts, pp. 620–621.

ON A NECESSARY CONDITION FOR THE MAINTENANCE OF OSCILLATIONS IN CLASS C LINEAR TRIODE OSCILLATORS.—A. P-T. Sah. (*Sci. Rep. Nat. Tsing Hua Univ.*, May, 1934, Vol. 2, No. 4, pp. 269–275: in English.)

The necessary condition is given by

$$\rho r / X_p(\mu X_g - X_p) < \tfrac{1}{2},$$

where μ is the amplification constant of the triode, ρ its internal plate resistance, r the effective resistance of the tank circuit, and X_p and X_g are respectively the plate and grid reactances which when multiplied by the fundamental oscillatory current give the alternating component of the plate and grid voltages.

THE MODULATION CHARACTERISTIC OF LINEAR TRIODE OSCILLATORS.—A. P-T. Sah. (*Ibid.*, pp. 227–287: in English.)

Author's summary:—It is shown that the amplitude of oscillation in a triode oscillator having linear plate and grid characteristics within proper limits is a linear function of the B-supply voltage and the grid biasing voltage when the plate current wave-form consists of portions of sine wave without flattened top. In the case of oscillators using a grid leak and condenser combination as bias, both the direct current taken by the plate and the oscillatory current output from the triode are directly proportional to the B-supply. Experimental curves on actual triodes are given to show the departure of actual modulation characteristics of triode oscillators from the ideal linear case.

GENERATOREN FÜR INFRA-LANGWELLEN (Generators for "Infra-Long" Waves [Frequencies around 1 Cycle/Second]).—I. J. Saxl. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, pp. 262–264.)

"One reason why the scientifically very interesting infra-long-wave region has been left almost unexplored may be that no immediate practical use for such waves is in sight. . . . Another reason may be that efficient generators of very simple construction are not generally known. In the present work, therefore, various methods of producing infra-long waves will be given." After mentioning Hartley's original single triode circuit and Moeller's push-pull modification of it (Abstracts, 1932, p. 163) the writer passes on to generators which do not involve valves, namely the series d.c. dynamo arrangement mentioned by Barkhausen and the derived arrangement of two d.c. dynamos (self-excited generator and separately-excited "condenser") devised by Hueter (1933, p. 36). He then describes the very simple and quite powerful generator which he himself has used successfully, in which an elastic metal strip stretched along, but not touching, a potentiometer is made to form a travelling contact with the latter by means of pressure from the end of a reciprocating rod driven by a small motor. The frequency and wave-form of the infra-long waves can be altered by simple means, and by the use of a transformer coupling an a.c. of higher frequency (*e.g.* a Faradic current) can be superposed on them so as to give a combination of biologically active currents for medical purposes.

RECEPTION

RESISTANCE TUNING [and Its Advantages over Reactance Tuning in Tuned R.F. Amplifiers: Constant "Best Compromise" Selectivity Curve over Whole Tuning Range and Much Greater Stage Amplification: Any Frequency below Maximum can be Tuned-In: Applicable also to Adjustable Audio-Frequency Oscillator: etc.].—S. Cabot. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 709–731.)

BEITRAG ZUR THEORIE DES FADING- UND LAUTSTÄRKEAUSGLEICHS (Contribution to the Theory of Fading Compensation and Automatic Volume Control [by Variable-Mu Valves and Fading Hexodes: Preliminary Communication]).—H. Zimmermann. (*Hochf:tech. u. Elek:akus.*, May, 1934, Vol. 43, No. 5, pp. 159–160.)

The variable-mu ("exponential") valve is first dealt with, and the equation for the regulation curve (relation between the peak r.f. voltage $\hat{E}$ and the detector output voltage V_R — and therefore the volume) is given in the upper frame on p. 159, the lower frame showing the relation between dV_R and $d\hat{E}$. The regulation curve equation, on certain simplifying assumptions, becomes $\hat{E} = V_R \cdot e^{|V_R|}$, giving the curve shown in Fig. 2.

The fading hexode is then dealt with, and the equation for its regulation curve is given in the frame on p. 160. With the same simplifying assumptions, and the assignment of a value 7, found in practice, for the regulating voltage V_{R0} for which the anode current becomes zero, this equation becomes $\hat{E} = V_R \cdot e^{|V_R|} / (7 - |V_R|)^{3/2}$ which gives the regulation curves shown in Fig. 6 for $p = \frac{1}{2}$ and $p = 1$ (in the fading hexode the bias applied to the 1st control grid is the full detector voltage V_R, while that applied to the

2nd control grid is $p \cdot V_R$, p being usually ½ or 1). Comparison of these curves with that of Fig. 2 for the variable-mu valve shows the superiority of the hexode (steeper rise, sharper change to an only slightly sloping part). This superiority is even better seen from the actual equations: with the variable-mu valve $\hat{E}$ only becomes infinity at the same time as V_R, while with the hexode it reaches infinity as soon as $V_R = V_{R0}/p$. This explains the fact that the fading hexode gives better regulation with little regulating voltage, and is thus doubly superior to the ordinary variable-mu valve.

The equation showing the relation between dV_R and $d\hat{E}$ for the hexode is given near the end of p. 160. This shows that (as with the variable-mu valve) dV_R becomes smaller as $|V_R|$ increases: with the hexode, however, V_R can never exceed the value V_{R0}/p. In order to avoid distortion by the appearance of grid current at the 1st control grid, $|V_R|$ must be at least as great as the maximum r.f. amplitude involved, $\hat{E}$. Consequently the r.f. amplification and coupling in the stages between hexode and rectifier must be suitably chosen. "An entirely complete regulation can naturally not be obtained with the fading hexode, nor with any automatic regulator: in practice, however, the volume changes can scarcely be detected."

Nogle Eksempler paa Beregning af Reguleringseffekten i Radiomodtagere med Automatisk Styrkeudligning (Calculation of the Regulation Effect in Radio Receivers with Automatic Volume Control).—S. A. C. Pedersen. (*Ingeniören*, 17th Feb. 1934, Vol. 43, No. 7, pp. 12–15.)

Author's summary:—To compensate for the variation in audio output with variation in field strength the desirable regulation curve for an automatic volume control system consists of a rising portion, which gradually approaches a horizontal line. In order not to affect the receiver sensitivity seriously at low field-strength levels, the first portion of the curve must have a fairly steep rise. When the regulation is carried out by means of a diode in connection with one or more h.f. valves, the calculation is carried out very conveniently by means of simple valve equations.

Starting from the functions $e_j = f_2(e_d)$ and $i_a = f_3(e_g)$ of diode and h.f. valve respectively, where e_j represents the rectified voltage, e_d the h.f. voltage, i_a the anode current and e_g the grid voltage, the author calculates the function $e_j = f_1(E)$, where E is the h.f. input voltage on the valve under regulation, which in turn is proportional to the field strength. The connecting equation is given by the definition of the h.f. amplification, $V = e_d/E$. Assuming the rectification characteristic of the diode to be a straight line, which is practically correct for the diode section of a Philips binode B2044, the calculation is carried through for various characteristics of the h.f. valve. It is shown that the i_a/e_g curve of a Philips h.f. pentode B2046 with very great approximation may be represented as $i_a = \gamma_1(e_g - E_g)^2$, and the corresponding curve for the variable-mu pentode B2047 with even greater approximation as $(i_a + a)(e_g + b) = c$, which is a hyperbola. With the aid of a graphical representation the effect of various cases are demonstrated, *e.g.* regulation on one or two valves of the form (a) $i_a = \gamma(e_g - E_g)^{3/2}$, (b) $i_a = \gamma_1(e_g - E_g)^2$ and (c) $(i_a + a)(e_g + b) = c$. The results derived are that the effect obtained with valves of the variable-mu type is not so desirable, as seen from the regulation standpoint, because the regulation is rather large at low levels; though such valves of course must necessarily be used to avoid cross-modulation, modulation-rise and modulation-hum. At low input voltages and with effective pre-selection the ordinary h.f. pentode is more suitable, and may be used to advantage with the above stated precautions.

Finally the use of fading-hexodes is mentioned briefly. In this case the input voltage is applied to a variable-mu characteristic, while the regulation voltage from the diode slides the working point down at a rate which is expressed by an equation of the approximate form $i_a = \gamma(e_g + E_g)^n$. Thus the advantages of both types of h.f. pentodes are combined.

Volume Control Improved by Switching-in Auxiliary Shunting Condenser across Aerial and Earth after Sunset.—Telefunken. (German Pat. 591 777: *Funktech. Monatshefte*, June, 1934, No. 6, p. 252.)

The Theory of the Mixing Hexode.—Kammerloher. (*See* under "Valves and Thermionics.")

Suppression of Interlocking in First Detector Circuits [Pentagrid Converter brings in New Causes of Interlocking: a New Circuit to reduce Interlocking, and a proposed Valve Structure with Same Object].—P. W. Klipsch. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 699–708.)

Shared Channel Broadcasting [and Its Interference: Heterodyning, Flutter, Sideband-Interference, and "Wobbling" (or "Roughness"): Experimental Study of Square-Law and Linear Detectors: etc.].—C. B. Aiken. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, pp. 7–10.)

"If the noise level is negligible, the limiting interference will be due to the undesired programme and the carrier ratio which is necessary will be of the order of 40 db, though just what value is required will of course depend upon the standards of excellence which are set up. If there is a moderate noise level at the receiving point, programme interference will still be the limiting factor, but it will be masked to a certain extent by the background noise, and consequently a higher level of interfering carrier will be permissible. As the noise level increases, this masking effect will become more pronounced and consequently the programme interference will become less important. However, if the interfering carrier is further increased, a flutter will appear at a ratio of about 28 db, in the case of a wide-band receiver, at about 24 db for a receiver of 3 500-cycle band width, and at higher levels of interfering carrier with still narrower bands. At very high noise levels the flutter will be the predominant form of interference, although if the interfering carrier is raised to about 15 db below the desired carrier there may also be distortion of the desired programme. This distortion and the flutter effect could be eliminated by synchronisation of the carriers of the two stations. This would unquestionably improve the service in certain outlying districts.

"These conclusions apply to receivers employing automatic gain control, but do not apply to those with a linear rectifier and manual control. In the latter case only the programme interference is of importance. However, receivers which have well-designed linear detectors almost invariably have automatic volume control."

Neuer Mess-Sender für Empfängeruntersuchungen (New Signal Generator [and Associated Equipment] for Investigations on Receivers).—J. Kammerloher. (*E.N.T.*, June, 1934, Vol. 11, No. 6, pp. 210–213.)

The signal generator itself (Fig. 1) consists of two stages, an inductively back-coupled oscillator (with grid condenser and leak so chosen that the frequency is practically independent of mains fluctuations, and with the interchangeable grid- and anode-coil unit thoroughly screened by a heavy copper cylinder) and a grid-modulated r.f. amplifier. The oscillator variable condenser C_1 is ganged with the amplifier condenser C_2: each has a logarithmic characteristic (*see* section 5 on the measurement of selectivity). The resistance R_K is so adjusted that its d.c. potential, acting on the grid, sets the working point of the modulated amplifying valve at the lower bend: the resulting anode current is seen in Fig. 2. The harmonics in this are filtered out by the oscillatory circuit $L_{a1} - C_2$, the potential oscillogram of which is given in Fig. 3. This circuit is so strongly damped by the resistance R_D that side-bands up to 10 000 c/s are transmitted without distortion. This increase of damping, combined with the screen grid, suppresses all tendency to oscillation, so that no neutralisation is necessary. The modulation is measured by a cathode-ray oscillograph (Kammerloher, Abstracts, 1932, p. 35, and January, p. 50): the anode circuit is coupled to the external ohmic potential divider (replacing the usual inductive regulation) through the coil L, the coil unit $L_{a1} - L$ being screened and interchangeable. To prevent radiation the whole signal generator, including the mains unit, is enclosed in a screening box of 2 mm-thick aluminium.

The 12-point potential divider is shown diagrammatically in Fig. 4. The characteristic impedance is only about 6 ohms, so that the inductive and capacitive effects can be neglected. The terminal resistance is made equal to the characteristic impedance, so that the network is free from reflection and the ratio of two successive voltages is constant over the whole length; this ratio is made $1/\sqrt{10}$. The steps are so engraved that the second is marked "1," the fourth "2," the sixth "3" and so on, so that six decadal steps are obtained, the intermediate steps being halves. The input potential is measured by a thermo-galvanometer with a full scale reading of 240 mv: this potential is adjusted by the potentiometer *Sp*. The whole potential-divider unit is screened with the utmost care, and the connection to the signal generator and to the receiver is by multiply-screened leads. The receiver itself is shielded from broadcasting station fields and any possible stray fields from the signal generator, by enclosure in a cage of galvanised iron wire. The mains connection to the receiver is short-circuited and earthed, for radio frequencies, by two condensers. The cathode-ray oscillograph is itself screened: it can be connected, at will, to note generator, signal generator, or receiver. The whole diagrammatic lay-out is seen in Fig. 5. Practical details concerning the procedure are given, with illustrating cases.

Entstörung der Strassenbahn (The Prevention of Interference [due to Sparking at Collectors] on Tramways: a suggested New Method).—F. Gabriel. (*Funktech. Monatshefte*, June, 1934, No. 6, pp. 219–220.)

The suggestion is to connect the trolley line, at the travelling point of contact, through a condenser to earth, to prevent the aerial action of the line. This cannot be done by means of the collector pulley itself, since the latter is separated from the line by the spark; it is therefore proposed to have a second pulley running just behind, and insulated from, the collector pulley. This earthing pulley would collect no current and would therefore run sparklessly: it would be connected through a condenser to the axles of the tram, and the two pulleys might be connected together through a second condenser. Damping resistances would perhaps be included in this connection and in the earthing connection.

Anti-Interference Devices at the Paris Fair: Sector Filter and "Filtrostat" Lead-Shielded Lead with Transformers.—Le Materiel Téléphonique. (*Electrician*, 8th July, 1934, Vol. 112, No. 23, p. 783.)

"Störschutz am Rundfunkempfänger in der Praxis" (Practical Protection of Broadcast Receivers against Interference [Book Review]).—H. Ike. (*L'Onde Élec.*, March, 1934, Vol. 13, No. 147, pp. 15–16A.)

A New Type of Quick-Search Radio Receiver [Special Superheterodyne Receiver with Two Frequency-Changes, First I.F. being Higher than Highest Signal Frequency, to avoid Image Channel Interference: for Short-Wave Telegraph Traffic with Ships calling on 0.25 Mc/s Bands between 8 and 18 Mc/s].—A. H. Mumford and H. Stanesby. (*P.O. Elec. Eng. Journ.*, July, 1934, Vol. 27, Part 2, pp. 122–128.)

Superheterodyne Tuning Condenser Design—for use in Multi-Range Receivers.—Schwartzmann and Burnell. (*See* under "Subsidiary Apparatus and Materials.")

Tracking Problems in All-Wave Superheterodynes [with Formulae for Design of Padding Circuits].—L. Martin. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, pp. 11 and 22.)

The Psychology of Tuning Scales with Station Names [leading to a Description of a New Type of Scale].—E. Henning. (*Funktech. Monatshefte*, June, 1934, No. 6, pp. 235–239.)

In the proposed arrangement the short-wave band, in which wavelengths are chiefly of significance, and the long-wave band, in which only about 10 stations have to be considered, each have a horizontal scale of their own, while the medium band has a " tabular " scale with diagonal slit.

GERMAN WIRELESS [Present General Trend of Receiver Design].—J. H. O. Harries. (*Wireless World*, 29th June, 1934, Vol. 34, pp. 449–450.)

HAIL, HIGH FIDELITY! [Paragraph on Philco High-Fidelity Receiver, 50–7 500 Cycles Range].—(*Electronics*, June, 1934, p. 192.)

THE UNIVERSAL SINGLE-SPAN RECEIVER.—W. T. Cocking. (*Wireless World*, 6th and 13th July, 1934, Vol. 34, pp. 6–9 and 18–21.)

Constructional details of a receiver for a.c. or d.c. mains based on the " Single-Span " principle dealt with in June Abstracts, p. 322. *See* also next abstract, and August Abstracts, p. 440.

SINGLE-SPAN DEVELOPMENTS.—W. T. Cocking. (*Wireless World*, 20th July, 1934, Vol. 34, pp. 38–40.) *See* also above.

EIN NEUER VOLKSEMPFÄNGER FÜR BATTERIEBETRIEB (A New, Battery-Driven " People's " Receiver [VE 301 B2, with Anode-Current Saving Circuit]).—W. Nestel. (*E.T.Z.*, 21st June, 1934, Vol. 55, No. 25, pp. 601–602.) Price, with 3 valves but without batteries, 65 R.M. For the quiescent circuit *see* also July Abstracts, p. 382, r-h column.

TWO-CIRCUIT THREE-VALVE ALL-MAINS RECEIVER FOR A.C. AND D.C. MAINS [with Selenium Rectifier in Greinacher Connection].—A. Ehrismann. (*Funktech. Monatshefte*, June, 1934, No. 6, pp. 239–243.)

EXPERIENCES IN THE ADAPTATION OF BATTERY-DRIVEN RECEIVERS TO MAINS-DRIVE [and the Design of a Satisfactory Mains Adaptor].—H. Ammer. (*Funktech. Monatshefte*, June, 1934, No. 6, pp. 244–246.)

THE ERICSSON CENTRALISED RADIO SYSTEM.—S. Friberg. (*Ericsson Review*, No. 2, 1934, pp. 89–92.)

AERIALS AND AERIAL SYSTEMS

EFFEKTIVHÖHEN VON EMPFANGSANTENNEN IM BEREICH VON SEKUNDÄRSTRAHLERN (The Effective Heights of Receiving Aerials in the Neighbourhood of Secondary Radiators [Iron Beams, Gutters, Water Pipes, etc.]).—A. Dennhardt and E. H. Himmler. (*Hochf: tech. u. Elek:akus.*, May, 1934, Vol. 43, No. 5, pp. 162–166.)

For a constant value of interference potential, the seriousness of interference decreases with an increase of the useful voltage taken by the aerial from the field produced by the transmitter. " Since the receiving system for ordinary broadcast reception finds itself in a radiation field affected by secondary radiators of all sorts and conditions, it is of importance to evolve some ' figure of merit ' with which to estimate quantitatively the various forms of aerials with regard to their powers of making use of the available field. For this purpose two questions must be answered: (1) how is the useful field around receiving aerials changed [by neighbouring secondary radiators]? and (2) how can the ' useful-field utilisation ' by the common types of aerial be represented quantitatively?"

Dealing with question (1) the writers point out that the nature of the field form near a secondary radiator depends very much on the ratio of the natural frequency of the radiator to the frequency of the exciting radiation field. Two cases are of special importance: (*a*) when the two frequencies are equal, and (*b*) when the radiator natural frequency is large compared with that of the field (the case of the " short " secondary radiator). The discussion of both cases can be limited to the behaviour of the electric vector in the close-up field of the secondary radiator, since most receiving sets are provided with short open aerials. Case (*a*) has been dealt with theoretically in 1913 by Rüdenberg, who replaced the secondary radiator by an equivalent dipole whose field was superposed on the primary field. There is then found, in the close-up field of the secondary radiator, an *increase* of the value of the electrical vector. In practice these conditions are liable to occur with tuned receiving aerials. As regards case (*b*) the theoretical and experimental work of Klimke (1928 Abstracts, pp. 97–99) is discussed: " short " secondary radiators produce a *decrease* of the vector. According to Klimke's results, " short " secondary radiators can be taken to mean that the field wavelength is not less than 12 times the height of the radiator.

The writers then describe the equipment used by themselves for the measurement of the electric vector of such fields. Such an equipment must not cause any serious change in the field; it must be easily transportable; and the procedure must be a simple one. The pick-up element used was a dipole whose length could be varied between 0.5 and 2 metres; it was connected to the apparatus by a two-cored screened h.f. cable 10 metres long. Great care was taken to make the input arrangements symmetrical. The calibration of the equipment is described. Field strength changes in the ratio of 1 : 1 000 are covered. Some results are given of measurements on the field forms near a 4-metres-high metal chimney pot (agreeing approximately with Klimke's result near an iron mast) and near the outside wall of a house, at different heights outside the house. Here the effect of the wall as a short secondary radiator is shown in Fig. 5: a decrease in field strength occurs as the wall is approached. The discrepancy between the shapes of the measured curves and Klimke's theoretical curve (Fig. 1b) is explained by the primary field being already distorted by the neighbouring buildings. Measurements *inside* houses showed that the average field strength fell from 100% (roof) through 70–80% (attics) and 50% and 20% (first and second floors) to 5–10% (ground floor) and 3–5% (cellars). The field strength also decreased away from the outer walls towards the middle of the house, and the electric vector was liable to rotation as a result, probably, of potential differences forming on various independent conductors—metal stanchions, lighting circuits, etc. In certain cases complete extinction of the field was met with.

Part IV deals with question (2)—the quantitative representation of the field utilisation by aerials. The ordinary "effective height" (given by the ratio of the aerial e.m.f. to the field e.m.f.) requires modifying before it is applicable to the usual broadcast receiving aerial, since—as has been shown above—the latter finds itself in an inhomogeneous, distorted field. The writers suggest the term "apparent effective height," given by the ratio of the aerial e.m.f. to the *undistorted* field e.m.f. (as would be measured, say, on the roof of the building). This quantity has a practical physical significance and can be employed for representing quantitatively the field-utilisation merit of an installation. Experimental results are given in measuring (with the same equipment as before) the "apparent equivalent heights" of different types of broadcast receiving aerials. "Floor" aerials (6 m horizontal with a 3-m vertical end) gave heights, in metres, ranging from 0.05 (cellar) and 0.09 (ground floor) to 0.14 (second floor) and 1.22 (attics); while for "apartment" aerials the values were 0.085 for the cellar, 0.16 for the ground floor, and 0.32 for the second floor: the best results were when the vertical part was as close as possible to the window. For both "floor" and "apartment" aerials the earths took the form of water or central-heating pipes: no important difference could be found. The use of a counterpoise earth usually decreased the effective height, which, moreover, varied with the coupling between this counterpoise and any secondary radiators: on one occasion the height could be changed in the ratio 1 : 16 by varying the coupling with a vertical stanchion. On other occasions it was found that the switching of the lighting system had a great effect, no doubt owing to the resulting changes in the distribution of currents and potentials in the network.

Other aerial systems tested were "improvised" combinations, acting as aerial and earth, of central-heating-system/water-pipes; sheathing-of-telephone-cable/water-pipes; and lighting-network/water-pipes. The telephone cable gave about the same effective heights (from 0.16 to 0.64) whatever the storey might be, while the heights given by the other combinations varied rather irregularly from storey to storey: apparently the best result was 0.77, given on the first floor by the central-heating/water-pipe combination. These results are discussed on p. 156.

NOTE ON SOME MEASUREMENTS OF THE RADIATION FROM SHIP STATIONS [Calculation of Radiated Power and Effective Height, from Day-Time Field-Strength Measurements and Propagation Formulae].—J. Marique. (*L'Onde Élec.*, March, 1934, Vol. 13, No. 147, pp. 149–156.)

"It is known that the Madrid Conference committee's curves correspond to the Sommerfeld/van der Pol formula for short distances and to the Watson/Eckersley formula for distances of some hundreds of kilometres. It was interesting to us to know which was preferable for wavelengths around 600 m and distances of 400 to 600 km." Table I shows that with the first formula the effective heights for four different ships, at distances between 400 and 505 km (of which the part over sea was of the order of one half), ranged from 11.5 to 16.5 m, the ratios of these heights to the geometrical heights lying between 0.287 and 0.4. Since it is generally taken that this ratio should lie between 0.3 and 0.5, it is concluded that the Sommerfeld/van der Pol formula worked well here ("though it would seem that the attenuation is a little greater than indicated by this formula"). With the Watson/Eckersley formula, on the other hand, the ratios ranged from 0.855 to 1.17, and the radiated powers came out larger than the nominal powers of the transmitters. This appears to be confirmed by the attitude of the Lucerne Conference committee, which says that the Madrid "day" curves should be taken as applying only to mid-day in summer: "in other seasons, particularly winter, and at great distances, the day values actually measured may be between the 'day' values and those of night, indicating that the ideal day conditions are not realised and that an indirect wave exists." The occasionally different values of effective height calculated by the same formula for the same ship are partly due to different orientations of the ship with regard to the receiver, bringing in the screening effect of the funnels (very clearly established in a special test).

Certain exceptionally high effective heights, calculated with the Sommerfeld/van der Pol formula, were found for positions close (within a mile) to Dover, and could only be explained by reflection of the waves by the cliffs there. "Since the wavelength was 660 m, and the cliffs are much higher than the ship's aerial, it is natural that the energy reflected should be important. The 'efficiency' of the reflector depends enormously on the distance of the aerial from the coast, and the favoured direction depends on the orientation of the cliffs." The polar diagram on p. 155 shows the way in which the effective height appears to vary as the position of the ship changes in relation to the coast line. "An immediate consequence of this phenomenon is that direction-finding bearings made in this region must be erroneous when the goniometer is affected by the reflected ray; this would be especially the case for goniometers on the French coast taking bearings on ships passing near the English coast, and equally for ships passing near Dover and taking bearings on the radio beacons on the French coast. It would be very interesting to collect observations on this subject."

THE POYNTING VECTOR AND THE ELECTROMAGNETIC THEORY OF ANTENNA RADIATION.—A. Press. (*Physik. Zeitschr. der Sowietunion*, No. 4, Vol. 5, 1934, pp. 607–615: in English.)

The Poynting vector is discussed to show that, strictly speaking, "radiation phenomena cannot be clearly treated without the use of the Heaviside-Maxwell system involving **e** and **h**. The so-called Lorentz-Maxwell equations avoiding the **e** and **h** concepts offer an insurmountable difficulty in this simple connection. Moreover the so-called 'equipartition of energy' theorem is also involved, so that it becomes necessary to point out that in a radiating system the co-ordinates cannot be strictly Lagrangian. A hydrodynamic analogue is employed to ease the understanding."

SCHEINWIDERSTAND VON ANTENNEN (The Impedance of Aerials [calculated on Line Theory]).—E. Siegel and J. Labus. (*Hochf: tech. u. Elek:akus.*, May, 1934, Vol. 43, No. 5, pp. 166–172.)

"The question of the determination of the reactance of an aerial has hitherto been very little dealt with in the literature; hints are indeed found in the work of various writers who are investigating the problem of radiation resistance, since in an examination of the energy flow near the surface of an aerial the radiation resistance is derived from the real component of this flow, and the reactance from the imaginary component. A more complete treatment on the reactance of aerials, based on a similar method, has been published by one of the present writers [Labus, Abstracts, 1933, p. 214]. If, however, reactance values thus calculated are compared with the results of practical tests [Schmidt, 1933, p. 160] it is found that in certain regions (if the aerial is fed at current nodes) somewhat serious discrepancies appear. Various considerations will account for these. In the first place the assumption of a sinusoidal current distribution along the aerial, hitherto made by all writers, is physically untenable, since it would involve null points of current on the aerial, and these in actual practice cannot exist except at the open ends. This assumption leads ultimately to the apparent existence of points of infinite value for the reactance, which are physically impossible. Secondly, the theory does not allow for the wavelength of an oscillation emitted by an aerial being different in space from its value in the aerial, since the propagation in space is with the velocity of light c, while along the aerial the velocity is reduced below c as a result of the emission of energy. Thirdly, the theory does not take into account the damping of the oscillation in its passage along the aerial, due to the radiation of energy: *i.e.* the gradual decrease of amplitude and change of phase of the current." The fact that the formulae for radiation resistance obtained according to the above theory are nevertheless satisfactory in practice would at first appear surprising: it is however due to the radiation resistance being always positive, whereas the reactance can take positive and negative values, the greatest errors occurring near the null points of reactance.

In the present paper the aerial is considered as replaced by an equivalent double line of constant characteristic impedance and an attenuation given by the radiation resistance. Thus an earthed vertical aerial of height h is replaced by a wire of length $l = 2h$, surrounded by free air, and fed at its centre with a sinusoidal potential of any frequency f, so that the wavelength of the oscillation along the wire ($\lambda = v/f$, where v is the propagation velocity along the aerial) can assume all possible values. At first sight it would seem uncertain whether this method would lead to practically useful results, since line theory assumes a constant characteristic impedance and an attenuation by an ohmic resistance uniformly distributed along the line, that is, a constant velocity of propagation along the line; whereas in an aerial the characteristic impedance increases steadily from the feeding point towards the end, the propagation velocity decreases steadily, and the contributions of the individual aerial elements to the radiation are different. It may however be stated that the method has given extensive, and in many cases unexpectedly exact, agreement with the measured values. Formulae for the resistance and reactance at the feeding point are derived, and the two quantities, and also the locus curves of aerial impedance, are shown in diagrams. In Fig. 7 the experimental values obtained by Schmidt (*loc. cit.*) are represented by the little crosses: the agreement with the calculated values is excellent. The important difference between the results given by examining the energy flow near the aerial and by the line method are illustrated by formulae 15 for the quarter-wave dipole. Various writers, using the first method, calculate the reactance as approximately 42.5 ohms, independent of the aerial dimensions, while the author's method gives it as approximately $3\,430/Z_a$; since Z_a (the characteristic impedance) is of the order of 800–1 000 ohms, this gives a much smaller value, and one, moreover, which is dependent on the aerial dimensions. Simple formulae are also given for the reactance and resistance of the simple dipole (quarter-wave aerial) and double dipole (half-wave aerial), and the reactive power requirement of an aerial is calculated (equation 27). Finally, a simple approximate formula (equation 29) is obtained for the velocity of propagation along the aerial.

In the above paper the treatment applies only to aerials without capacitive loading at their top ends. In the following paper [*see* below] the theory is extended to aerials which are so loaded: in a final section the tuning of the aerial, and the necessary components, are dealt with.

SCHEINWIDERSTAND VON BESCHWERTEN ANTENNEN (The Impedance of Aerials Loaded with Top Capacity).—E. Siegel. (*Ibid.*, pp. 172–176.) *See* end of preceding abstract.

DER SCHEINWIDERSTAND AM EINGANG VON HOCHFREQUENZKABELN (The Impedance at the Input End of High-Frequency Cables).—W. Kautter. (*Funktech. Monatshefte*, June, 1934, No. 6, pp. 217–219.)

DIRECTIONAL BROADCASTING [as at WFLA: Certain Practical Difficulties and Their Elimination].—R. M. Wilmotte. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, pp. 12–14.)

For a previous paper *see* 1933 Abstracts, p. 158. Among the points which have to be considered in designing the coupling circuits are the facts that physically identical aerials may have different resistances and reactances (by as much as 30% at WFLA); further, that the cancellation of the two radiations, in the true backward direction, occurs accurately at one frequency only, and one sideband may actually be reversed—causing enough distortion to render speech unintelligible. A less close phase adjustment increases the carrier, both sidebands become positive (though they may not have the same length) and the distortion rapidly diminishes.

AERIALS FOR INCREASING THE FADING-FREE ZONE OF BROADCASTING STATIONS.—H. Wehrlin. (*Bull. Schweiz. Elektrot. Ver.*, No. 5, Vol. 25, 1934, pp. 129–131.)

VALVES AND THERMIONICS

WASSERGEKÜHLTE SENDEROHREN—GROSSLEISTUNGSROHREN (Water-Cooled Transmitting Valves—High-Power Valves [with Long List of Literature and Patent References]).—F. Banneitz and A. Gehrts. (*E.N.T.*, June, 1934, Vol. 11, No. 6, pp. 214–231.) From the German Post Office.

VACUUM TUBES FOR GENERATING FREQUENCIES ABOVE 100 MEGACYCLES [Ultra-Short and Micro-Waves: "Appreciable Power" at 1 000 Mc/s (Negative Grid) and 6 Watts at 500 Mc/s: etc.].—C. E. Fay and A. L. Samuel. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, p. 679: short abstract only.)

THE THEORY OF THE MIXING HEXODE.—J. Kammerloher. (*Hochf:tech. u. Elek:akus.*, May, 1934, Vol. 43, No. 5, pp. 161–165.)

Author's summary:—In sections I to VI the theory of the mixing hexode is developed from the d.c. characteristics $I_a = f(U_1, U_4)$. In contradiction to Hasenberg [*Funk*, 1933, No. 21, p. 333: *see* also April Abstracts, p. 211, l-h col.] it is found that three 'objectified' frequencies appear ["objectification" is a term given by Rukop to the transference of the modulation frequency to the intermediate frequency], namely $(f_1 + f_2)/2$, $f_1 + f_2$, and $f_1 - f_2$: their current amplitudes depend chiefly on $S_1 . \mathfrak{U}_1$, $S_4 . \mathfrak{U}_4$, and $\Delta S_1/\Delta U_4 . \mathfrak{U}_1 . \mathfrak{U}_4$. For the production of the intermediate frequency $f_1 + f_2$ or $f_1 - f_2$ only the second quantity is of importance. In analogy to the well-known rectification relation $\Delta S/\Delta U . \mathfrak{U}^2$ we may here speak of a 'reciprocal' rectification. The change of slope $\Delta S_1/\Delta U_4$ shows (as in the ordinary rectification $\Delta S/\Delta U$) a distinct optimum, which in this case, of course, unlike the latter case, is dependent on the two grid biases U_1 and U_4 (*see* Fig. 8). Since it is usual to choose $f_1 - f_2$ as the intermediate frequency, we have for its anode alternating potential $\mathfrak{U}_{az}$, for a modulated input alternating potential $\mathfrak{U}_1 . (1 + m \sin \omega_m t)$, the relation $\mathfrak{U}_{az} = -\frac{1}{2} . \Delta S_1/\Delta U_4 . \mathfrak{R}_a . \mathfrak{U}_4 . \mathfrak{U}_1 . (1 + m \sin \omega_m t) . \cos(\omega_1 - \omega_2)t$, and for the amplification ratio the relation $v = \frac{1}{2} . \Delta S_1/\Delta U_4 . \mathfrak{R}_a . \mathfrak{U}_4$. In section VII the theoretical results are established by experiment.

SUPPRESSION OF INTERLOCKING IN FIRST DETECTOR CIRCUITS [Pentagrid Converter brings in New Causes of Interlocking: a New Circuit to reduce Interlocking, and a proposed Valve Structure with Same Object].—P.W. Klipsch. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 699–708.)

IMPROVEMENTS IN MULTI-ELECTRODE VALVES [such as the Diode-Triode: Two Different Cathodes deposited on Different Parts of a Common Rod of Refractory Material, perforated by Two Canals carrying the Heating Loop].—J. Visseaux and A. L. le Menestrel. (French Pat. 763 043, pub. 23.4.1934: *Rev. Gén. de l'Élec.*, 30th June, 1934, Vol. 35, No. 26, p. 214 D.)

EXPERIMENTAL STUDIES ON CLASS A AMPLIFIER [Optimum Operating Conditions of Radiotrons with Subnormal Filament Emission].—Y-Y. Sha: Sah. (*Sci. Rep. Nat. Tsing Hua Univ.*, May, 1934, Vol. 2, No. 4, pp. 289–301: in English.)

Verification of the analytical solutions obtained by Sah (February Abstracts, pp. 89 and 95, l-h columns).

EXAMINATION OF SOME TWO-GRID VALVES FOR A BRIDGE-CIRCUIT AMPLIFIER [for Photocell Currents].—H. Saïni. (*Physik. Ber.*, 1st June, Vol. 15, No. 11, p. 891.)

A MODULATION-NOTE METHOD FOR THE RAPID DETERMINATION OF THE SECOND DIFFERENTIAL COEFFICIENT OF A CURRENT/VOLTAGE CHARACTERISTIC.—Müller. (*See* end of abstract under "Transmission.")

AUTOMATIC VOLUME CONTROL BY THE EXPONENTIAL (Variable-Mu) VALVE AND BY THE FADING HEXODE: THEORETICAL TREATMENT AND COMPARISON OF MERIT.—Zimmermann. (*See* abstract under "Reception.")

EXPERIMENTAL STUDY OF THE FLUCTUATIONS OF RESISTANCE IN A METALLIC CONDUCTOR OF SMALL VOLUME.—J. Bernamont. (*Comptes Rendus*, 18th June, 1934, Vol. 198, No. 25, pp. 2144–2146.) Further development of the work dealt with in July Abstracts, p. 385. The conductor is now a 1 micron diameter platinum wire.

POSITIVE AND NEGATIVE THERMIONIC EMISSION FROM COLUMBIUM.—H. B. Wahlin and L. O. Sordahl. (*Phys. Review*, 15th June, 1934, Series 2, Vol. 45, No. 12, pp. 886–889.)

THE SURFACE IONISATION OF POTASSIUM ON TUNGSTEN [Assumed Increase of Work Function of Tungsten with Temperature].—A. L. Reimann. (*Phys. Review*, 15th June, 1934, Series 2, Vol. 45, No. 12, p. 898.)

This letter points out that it is possible to reconcile the results of Copley and Phipps (June Abstracts, p. 331, r-h col.) with theory, if the work function of tungsten is assumed to have substantially higher values in the operating range of temperature than that corresponding to the slope of the Richardson line.

DIRECTIONAL WIRELESS

MARCONI DIRECTION FINDER TYPE D.F.9C [for Submarines].—H. A. Ewen and F. Woods. (*Marconi Review*, May/June, 1934, No. 48, pp. 1–8.)

DIRECTION-FINDING ERRORS DUE TO REFLECTION FROM DOVER CLIFFS.—Marique. (*See* end of abstract under "Aerials and Aerial Systems.")

ACOUSTICS AND AUDIO-FREQUENCIES

ÜBER DIE BERECHNUNG DES WIRKUNGSGRADES STROMDURCHFLOSSENER KOLBENMEMBRANEN (The Calculation of the Efficiency of Current-Carrying Piston Diaphragms [for Giant Loudspeakers]).—H. Neumann and K. Warmuth. (*E.N.T.*, May, 1934, Vol. 11, No. 5, pp. 178–187.)

The use of low-tuned piston diaphragms with electrodynamic drive is well known since the work of Riegger and of Rice-Kellogg, but full advantage has not been taken of this type of drive, since the diaphragm has only been driven at individual points by special current-carrying conductors, with the result that partial vibrations have been set up. The ribbon loudspeaker was a step in the right direction, but to obtain a large volume of sound with a surface of only 7 cm^2 involved very large amplitudes, especially at low frequencies, and with the weak ribbon this caused a limitation of the available power. The writers have therefore made a loudspeaker with a thin aluminium diaphragm of large area (2 400 cm^2) which itself carries the current, the strong uniform magnetic field being produced by eight long flat field coils spaced so as to surround, in all, about 65% of the diaphragm surface.

In the present paper the influence, on the efficiency of this loudspeaker, of diaphragm thickness, frequency, magnetic field and diaphragm area is examined. It is found that :—(1) There exists a minimum of exciting (field) power, for a given diaphragm area, whose position depends on the height of the field windings (*i.e.* the total height parallel to diaphragm). (2) Loudspeakers with current-carrying diaphragms give frequency curves whose range downwards (owing to the possibility of obtaining larger amplitudes) and upwards (owing to the smaller total moving mass) is greater than those of diaphragms with separate current-carrying conductors. On the other hand they have the disadvantage of requiring a larger field power. Thus two giant Blatthaller speakers delivering 0.1 watt of acoustical power were found to give, without distortion, no lower frequencies than 43.8 and 31 c/s, whereas the new speaker with the same diaphragm area could reproduce down to 11.3 c/s ; but to obtain an efficiency of 5% the field power would have to be 9.5 kw. This power could be reduced by the use of say, a 1 550 cm^2 or 480 cm^2 diaphragm, raising the lowest frequency to 14 and 25.2 c/s respectively.

Electrodynamic [Loud-] Speaker Design Considerations [Measurements to determine Efficiency of a Diaphragm and Optimum Mass of Its Voice Coil : then the Selection of Coil Diameter and Magnet Dimensions for Minimum Cost].—J. D. Seabert. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 738–750.)

Investigation of a Vibrating Membrane by means of Optical Interference [with Phase Control by Synchronous Stroboscopic Disc : Investigation of Stretched Steel Disc with Exciting Frequencies 500–1 100 c/s].—P. Paasche. (*Physik. Ber.*, 15th June, 1934, Vol. 15, No. 12, p. 930 : Cologne Dissertation.) For an earlier paper *see* 1928 Abstracts, p. 695.

Improving the Broadcast of (Disc) Recorded Programmes [Deficiency of Lower Frequencies corrected by Filter and Attenuator : Strikingly Improved Transmission, free from Resonance Peaks and " Boom "].—G. H. Miller. (*Electronics*, June, 1934, p. 178.)

The March towards High Fidelity in Sound [Comparative Charts from 1920 Phonograph to 1934 Wide-Range Sound Pictures].—Electrical Research Products. (*Electronics*, June, 1934, p. 185.)

Turning the Record.—E. C. Wadlow. (*Wireless World*, 15th and 22nd June, 1934, Vol. 34, pp. 406–408 and 432–434.)

Quality of reproduction from gramophone records is seriously influenced by variation in motor speed caused by alterations in retarding torque at the needle point. The author deals with the various factors which determine these alterations in torque.

Electro-Magnetic Method of Sound-on-Film Recording by Cutting the Edge of the Film.—R. Nublat. (French Pat. 762 707, pub. 16.4.1934 : *Rev. Gén. de l'Élec.*, 30th June, 1934, Vol. 35, No. 26, pp. 213–214D.)

Home-Recording on 16-mm Film [Recent Commercial Developments in Sound-Film Cameras and Projectors, in America and Europe].—(*Electronics*, June, 1934, p. 176.)

Photoelectric Talking Machines [for Short Phrases and Time Indication on Telephone Networks : replacing Magnetic Reproducers].—C. Ahlberg. (*Ericsson Review*, No. 2, 1934, pp. 85–88.)

Theory of Sound in Voice Tubes with Radiating Walls.—A. Press. (*Physik. Zeitschr. der Sowietunion*, No. 4, Vol. 5, 1934, pp. 616–634 : in English.)

The Electronic Organ [particularly the Coupleux-Givelet Organ].—A. Givelet. (*L'Onde Élec.*, April, 1934, Vol. 13, No. 148, pp. 157–171.)

The Home-Construction of a Trautonium.—W. Funkhusen. (*Funktech. Monatshefte*, June, 1934, No. 6, pp. 247–250.)

Die Struktur des Holzes in Violinen (Wood Structure in Violins).—K. Lark-Horovitz and W. I. Caldwell. (*Naturwiss.*, 29th June, 1934, Vol. 22, No. 26, pp. 450–451 : *Nature*, 7th July, 1934, Vol. 134, p. 23.)

X-ray investigations of many different violins have shown that a really good instrument may be regarded as a system of two coupled plates ; the velocity of sound in the top has different values in directions parallel and perpendicular to the grain, while that in the back is the same in all directions.

The Sound Radiation from a Condenser Discharge.—W. McFarlane. (*Phil. Mag.*, July, 1934, Series 7, Vol. 18, No. 117, pp. 24–46.)

The work described in this paper was undertaken to determine the relation between the intensity of the sound emitted by a condenser discharge and the electrical constants of the circuit employed, and to study the propagation of the spark-pulse. The impulse is found to be given by the formula $P = AV^2\sqrt{C/LR}$, where A is a constant for any given electrodes and V the voltage across the condenser of capacity C discharged through inductance L and resistance R.

The Helmholtz Resonance Theory of Hearing.—E. B. Wedmore. (*Nature*, 30th June, 1934, Vol. 133, p. 983.)

The resonance theory of hearing, discussed by Hallpike and Rawdon Smith (June Abstracts, p. 329), does not explain the feature that the human hearer cannot name the harmonics in a compound tone unless these harmonics are made large enough to cause actual reversal of the primary wave. A closer examination of the process and mechanism of the travel of sound throughout the length of the cochlea is suggested by an apparatus designed by Max Meyer before 1898.

Scientific Studies of Noise.—G. W. C. Kaye. (*Nature*, 28th July, 1934, Vol. 134, pp. 149–150 : note on lecture.)

" Modern Acoustics " [Book Review].—A. H. Davis (*Journ. Scient. Instr.*, July, 1934, Vol. 11, No. 7, p. 237.)

" Applied Acoustics " [Book Review].—H. F. Olson and F. Massa. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, p. 22.)

Audio-Frequency Measurement by the Electrically-Excited Monochord [Resonant Frequencies by no means Exact Multiples of Fundamental : Discrepancy traced to Imperfect Flexibility of Wire : Simple Expression for these Frequencies, involving Young's Modulus, and a Simple Method of measuring This].—E. Williams. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 794–804.) Supplementing Harries's work (1929 Abstracts, p. 638).

Single-Valve Beat-Frequency Oscillator using the Duodynatron Tetrode.—Hayasi. (*See* abstract under " Transmission.")

Resistance Tuning and Its Use in an Adjustable Audio-Frequency Oscillator.—Cabot. (*See* abstract under " Reception.")

Audio-Frequency Test Oscillator [for Battery or A.C. Mains Supply].—M. G. Scroggie. (*Wireless World*, 20th and 27th July, 1934, Vol. 34, pp. 34–36 and 64–66.)

Home-Made Signals [Details of Simple Modulated Oscillator].—E. J. King. (*Ibid.*, 13th July, 1934, Vol. 34, p. 21.)

A New Indicating Harmonic Analyser [Tuned Coupled Circuits with Thermo-Milliammeter in Secondary : measuring up to 30th Harmonic (greater than 0.05 Volt) of a Fundamental of 50 or 60 c/s : No Amplifier required].—M. Doté and Y. Nakamura. (*Physik. Ber.*, 15th June, 1934, Vol. 15, No. 12, p. 967.)

Erfahrungen bei der Messung der Schalldurchlässigkeit eines Orgelprospektes (Experiences in the Measurement of the Sound Transmission in Front of an Organ [Effects of Wooden Screens, Walls, etc.]).—J. Schumacher. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, pp. 274–279.)

Apparatus for the Determination of Cinema Characteristics [Portable Equipment for Acoustical Survey].—C. A. Mason and J. Moir. (*BT-H Activities*, May/June, 1934, Vol. 10, No. 3, pp. 77–81.)

Telephony by Supersonic Waves through Water.—Marro. (*See* last abstract under " Miscellaneous.")

Sources of Error in Optical Investigations of Acoustic Fields. I. The Temperature Gradient in Front of the Oscillating Quartz Crystal.—C. Bachem and E. Hiedemann. (*Zeitschr. f. Physik*, 1934, Vol. 89, No. 7/8, pp. 502–505.)

" Band Receivers " for Carrier-Current Telegraphy and Other Purposes.—Kajii and Matsumae. (*See* abstract under " Miscellaneous.")

Terminal Equipments [for Radio-Telephone Circuits : General Considerations, and the Marconi R.C. 49 Equipments].—(*Marconi Review*, May/June, 1934, No. 48, pp. 20–29 : to be continued.)

Complex Magnetic Cross-Talk Couplings in Telephone Cables [due to Eddy Currents in the Lead Sheathing].—G. Wuckel. (*E.N.T.*, May, 1934,, Vol. 11, No. 5, pp. 157–171.)

PHOTOTELEGRAPHY AND TELEVISION

Über den kontinuierlich arbeitenden Zwischenfilm-Grossprojektionsempfänger (On the Continuously Acting Intermediate-Film Large-Picture Projecting Receiver [Its Difficulties and Recent Improvements]).—G. Schubert : Fernseh Company. (*Funktech. Monatshefte*, June, 1934, No. 6, Supp. pp. 27–30.)

Recent developments of the system referred to in January Abstracts, p. 45, l-h col. Since the 1933 Berlin Exhibition the number of lines has been increased from 120 to 180, which means that the exposure time (for 25 picture changes per sec.) has been decreased to one millionth of a second. The resulting difficulties are discussed, and the way in which many of them have been overcome. " Owing to reasons given above, the range of darkening does, frankly, leave something to be desired. While with an ordinary positive film, such as is used for cinema projection, the darkening amounts to 1.5 (that is, the lightest and darkest parts of the image have a ratio of about 1 : 30), in the pictures recently obtained with the large-image projector the value is about 0.5 to 0.6 (that is, a darkening range of 1 : 4 or 1 : 5). In the latest cathode-ray tube pictures the range is about 1 : 10. Work is going on at present to increase the range for the projector images." The apparatus gives 5 to 8 hours of continuous working, the total length of film being about 70 metres : the solutions last several days. The possibility of replacing the arc lamps and Kerr cells by high-vacuum cathode-ray tubes is briefly discussed at the end of the paper. The work of von Borries and Knoll has shown that with an anode voltage of about 10 kv and a ray current of about 2 mA a darkening range of about

1 : 10 can be obtained : this should be considerably increased by the use of voltages up to 50 kv, so that a range of 1 : 30 should not be unattainable, though such tubes would require special intensity-control methods.

A VELOCITY-MODULATION TELEVISION SYSTEM.—L. H. Bedford and O. S. Puckle. (*Journ. I.E.E.*, July, 1934, Vol. 75, No. 451, pp. 63–82 : Discussion pp. 83–92.)

The full paper, summaries of which have already been dealt with (*see* May Abstracts, p. 275). At the end of the paper the writers say : " The present basis of operation at the transmitter appears to limit the picture subject-matter to film material. As previously mentioned, this restriction is not considered to be of much significance, because a television service is subjected to the same limitation on account of the following considerations. (*a*) Owing to the large frequency band the service must necessarily be on ultra-short waves . . . this means . . . a moderately large number of local transmitters. The subject matter must therefore be in a form which can be easily sent about from place to place. (*b*) Topical events must constitute an important item of an entertainment television service, and only a negligibly small proportion of these can be 'brought into the studio.' Direct television transmission from the site, even if it were technically possible, would hardly be of much value on account of considerations of 'time of day.' " If, however, direct transmission is still desired, both the Farnsworth and Zworykin cathode-ray scanning methods seem to be basically suitable for application to the velocity-modulation principle (*see* later). Replying, in the Discussion, to Willans's suggestion regarding intermediate-film transmission, the writers say that the demonstrations which they saw in Berlin " were rather unsatisfactory, though possibly capable of improvement " : and they consider Willans to be " not entirely justified in comparing television with sound broadcasting, when he says that the listening public exhibit an unmistakable preference for real artists as distinct from gramophone records " : a more suitable comparison would be between the theatre and the cinema. Regarding mechanical transmission they " can see no reason whatever why it should be considered necessary or even desirable to carry out a purely electrical job in a mechanical way, especially when such a method brings in so many extra difficulties which would not otherwise be encountered. For instance, with velocity modulation the synchronisation problem is inherently solved. . . . " Other points dealt with in the Discussion are : the way in which the iconoscope could be used with velocity-modulation : the independence of after-glow and aperture effects : the relative band widths required for the velocity and intensity methods : and many others.

VELOCITY MODULATION IN TELEVISION [Theoretical Note].—E. E. Wright. (*Proc. Phys. Soc.*, 1st July, 1934, Vol. 46, Part 4, No. 255, pp. 512–513 : Discussion p. 514.)

Author's abstract :—The motion of a spot of light of constant intensity, necessary to produce the effect of a sinusoidal linear distribution of light and intensity on a television viewing screen, is [theoretically] determined and the effect of the finite size of the scanning spot is compared with the analogous effect in the more usual type of television system in which the scanning spot moves with constant speed and is modulated in intensity.

FERNSEHEMPFANG IN GROSS-BERLIN (Television Reception in Greater Berlin [Tests on Witzleben U.S.W. Transmissions]).—W. Scholz. (*Funktech. Monatshefte*, June, 1934, No. 6, Supp. pp. 25–27.)

With an aerial power of about 4 kw (long dash) and an aerial 138 m above the ground, the 6.985 m transmissions gave a satisfactory practical range of about 60 km—that is, about 50% greater than the " optical " range, although in none of the numerous tests, in all kinds of weather, was any symptom of space wave (fading, etc.) found. Similarly when the television receiver was raised on a tower 50 m above the ground good reception was possible at 100 km, when the " optical " range was 65 km. *Cf.* section 5 of Heinrich-Hertz Society abstract, June Abstracts, pp. 338–339.

TELEVISION NEARS TECHNICAL SOLUTION [RCA Victor Papers and Demonstrations at Philadelphia Convention : the Great Cost of Programmes—Who is to Pay : the Importance of the Iconoscope : Wide-Band Cable of Plated Steel Wire for the " Video " Signal Bands : etc.].—(*Electronics*, June, 1934, pp. 172–173.)

OPTICAL EFFICIENCIES AND DETAIL IN TELEVISION SYSTEMS. PART II. [Extension to Indirect Scanning : the Effect of Aperture Distortion on Detail].—N. Levin and L. E. Q. Walker. (*Marconi Review*, May/June, 1934, No. 48, pp. 9–19.) For Part I *see* July abstracts, p. 390, r-h column.

" TELEVISION FOR THE AMATEUR CONSTRUCTOR " [Book Review].—H. J. Barton Chapple. (*L'Onde Élec.*, April, 1934, Vol. 13, No. 148, p. 22A.)

THE CATHODE-RAY TUBE AS A PROBLEM OF GEOMETRICAL ELECTRON-OPTICS [Compressed Survey of Important Points, with References : Properties and Use of " Aperture," " Immersion," and " Single " Lenses : etc.]—E. Brüche. (*Archiv f. Elektrot.*, 7th June, 1934, Vol. 28, No. 6, pp. 384–390.)

TRANSMISSION OF PICTURES BY MEANS OF MOBILE TRANSMISSION SETS [Recent Results].—J. Stratton. (*P.O. Elec. Eng. Journ.*, July, 1934, Vol. 27, Part 2, pp. 112–115.)

PRODUCTION OF LIGHT FROM DISCHARGES IN GASES [in connection with Sodium-Vapour Lamps].—S. Dushman. (*Gen. Elec. Review*, June, 1934, Vol. 37, No. 6, pp. 260–268.)

FUNDAMENTAL PHENOMENA IN SODIUM-VAPOUR LAMPS.—C. G. Found. (*Ibid.*, pp. 269–277.)

Sur les Cellules photoélectriques dites à Couche d'Arrêt (On the so-called "Barrier Layer" Photoelectric Cells [Photoelectric Effect (in Selenium Cells) Independent of Rectifying Effect : Temperature Coefficient higher in Cells with higher Rectifying Power : Cells constructed with practically No Rectifying Power]).—Roy-Pochon. (*Comptes Rendus*, 11th June, 1934, Vol. 198, No. 24, pp. 2083–2084.)

A New Photoelectric Effect in Cuprous Oxide [in a Magnetic Field].—I. K. Kikoin and M. M. Noskow. (*Physik. Zeitschr. der Sowietunion*, No. 4, Vol. 5, 1934, pp. 586–596 : in English.) For a preliminary communication *see* Abstracts, 1933, pp. 454–455. *See* also Joffé, 1933, p. 455 : and next abstract.

On the Explanation of the Photomagnetic-Electric Effect in Semi-Conductors [*see* preceding abstract].—J. Frenkel. (*Ibid.*, pp. 597–598 : in English.)

A "simple explanation which is quite different from that proposed by the above authors" and is based on the present writer's hypothesis that the positive holes left by the escaping electrons have a large mobility, comparable with that of the free electrons themselves (the motion of the holes being actually due to the jumping of the bound electrons from a neighbouring atom to a positive ion).

Über die Gesetzmässigkeiten lichtelektrischer Absorption (The Laws of Photoelectric Absorption).—F. Hlučka. (*Zeitschr. f. Physik*, 1934, Vol. 89, No. 7/8, pp. 497–501.)

For previous papers by the writer *see* 1933 Abstracts, pp. 335 and 631, r-h columns. The present paper expands the idea that the exchange of light energy into electrical energy occurs, in the external photoelectric effect with non-conductors, only at the surface of the cathode.

X-Ray Wavelengths from Crystals and Ruled Gratings [Photoelectric Energies computed from Crystal Spectra compared with Those Observed].—A. E. Ruark. (*Phys. Review*, 1st June, 1934, Series 2, Vol. 45, No. 11, pp. 827–831.)

MEASUREMENTS AND STANDARDS

Einfache Näherungsformeln für die Eigenkapazität mehrlagiger Spulen (Simple Approximate Formulae for the Self-Capacity of Multi-Layer Coils).—H. Zuhrt. (*E.T.Z.*, 5th July, 1934, Vol. 55, No. 27, pp. 662–665.)

The formulae arrived at are sufficiently accurate for practical purposes, since with multi-layer coils an accuracy within 10–20% for the self-capacity is all that can be reckoned on, owing to the dependence on the relative positions of the wires and on the dielectric constant. The writer begins by deriving formulae for the self-capacity of single-layer coils by a combination of well-known inductance formulae and the formulae for the natural wavelengths of single-layer coils, previously obtained by himself (Abstracts, January, p. 48, r-h column : *see* also May, p. 265). These latter are given in formulae 5, for medium and broad flat coils and for cylindrical and narrow flat coils respectively. Working out the values of self-capacity from $\lambda = 2\pi\sqrt{LC}$ for various values of R/l from 0.25 to 10 (R being the mean winding radius and $2l$ the winding length—or breadth in the case of the flat coils), it is seen (table 1) that for practically all single-layer coils the value of C/R is almost constant, and that within a small percentage, for all such coils except very long cylindrical and very large flat coils, the self-capacity is given by $C = 0.48 \, R \, . \, 10^{-12}$ Farad.

With flat coils and short cylindrical coils the electrical energy is equally divided on both sides of the coil, so that each side has a capacity of half the above amount. With long cylindrical coils a similar distribution can be reckoned on approximately. The values of self-capacity thus obtained are for isolated coils with air dielectric : the increased capacity due to wire insulation, former, table, etc., is then allowed for approximately by introducing a factor ϵ_m (defined by equations 7 and 7a) so that the partial capacities on each side of the coil is given by $C_{1,2} = \epsilon_m \, . \, 0.24 \, R \, . \, 10^{-12}$ Farad.

This single layer formula is then, in Part III, applied to the solution of multi-layer coils, by an investigation of the electrical fields between the individual layers of such a coil, the layers being treated as approximating to plate condensers with "corrected" gaps. Long narrow cylindrical coils are dealt with first, and formulae 9 and 10 are derived (for aiding-wound coils and continuously-wound coils respectively, the inter-layer capacity component of the whole capacity being 4/3 times as great in the latter as in the former) involving partial capacities obtainable by use of the single-layer formula. A similar formula is then obtained (12) for a continuously-wound wide cylindrical or multi-layer flat coils : with the deletion of the 4/3 this applies to aiding-wound coils. The results are confirmed by measurements (table 2) on 11 different coils.

Über eine einfache Methode zur Bestimmung der Selbstinduktion und Kapazität von Ubertragern und Spulen mittels Kathodenoszillographen (A Simple Method of Measuring the Inductance and Capacity of Transformers and Coils by means of the Cathode-Ray Oscillograph).—W. Nowotny. (*Hochf:tech. u. Elek:akus.*, June, 1934, Vol. 43, No. 6, pp. 208–210.)

The method described gives rapid results of sufficient accuracy for many practical purposes (testing and selecting transformers and inductances in the manufacture of amplifiers, filters, etc.). Apart from the simplicity of the circuit required, it has the advantage over bridge methods (where for every test point ohmic and reactive components have to be balanced) that only one quantity, the frequency, has to be adjusted.

In Fig. 1 the open-circuit resistance of the transformer is represented by the combination of the impedance of a damped fly-wheel circuit (parallel connection of the main inductance L, the self-capacity C, and the dissipative resistance R) and the impedance made up of the winding resistance (referred to the primary side) and the leakage inductance l. A resistance R_v is connected in series with the primary winding, and the whole circuit is excited by a note-frequency generator. The voltage appearing across R_v is taken to the horizontal plates of the oscillograph, and the secondary voltage to the vertical plates. Then if the exciting frequency is varied from zero to infinity, the oscillograms shown in Fig. 4 are obtained : at the extreme low and high frequencies the ellipses become horizontal straight lines, but at the fly-wheel resonant frequency ω_1 ($= 1/\sqrt{LC}$, since the leakage inductance l is nearly always much smaller than the main inductance L, especially in transformers for communication technique) they become a sloping straight line. The coincidence of the exciting frequency with the fly-wheel resonant frequency can thus be obtained by adjusting the former till the screen figure becomes as thin a straight line as possible.

To measure the self-capacity C the exciting frequency is set at $\omega_1\sqrt{2}$ (ω_1 having been obtained as just indicated) : by means of a variable condenser enough capacity is then added on the secondary side to make the screen figure again a thin straight line. The added capacity is then equal to C_2, the self-capacity of the transformer referred to the secondary side. With C known, the self-inductance is then obtained from the fly-wheel resonant frequency. Finally, the value of the ohmic resistance R can be obtained from the slope a of the straight-line screen figure, since tan $a = \ddot{u} \,.\, R/R_v$, where $\ddot{u}$ is the transformation ratio : this only holds if R_v is not too large, otherwise the paralleled resistance of the tube itself will affect things. On p. 210 it is explained why the circuit described must be employed, instead of a direct connection of the transformer windings to the oscillograph plates, and the paper ends by discussing (with examples) some applications of the method.

Coil Design for Short-Wave Receivers : a Study of 15 Mc Inductances [Effect of Wire Diameter : Relation between Q and Wire Diameter and Winding Length : Effect on Q of Neighbourhood of Chassis : Effects of Shielding Can : Wave-Change Methods].—W. S. Barden and D. Grimes. (*Electronics*, June, 1934, pp. 174–175 and 196.)

On the Measurement of the Resistance of Circuits oscillating at High Frequency [and the Discrepancies between the Three Usual Methods].—M. Beauvilain. (*L'Onde Élec.*, March, 1934, Vol. 13, No. 147, pp. 127–148.)

Author's summary :—" The resistance of an oscillating circuit is measured, in practice, by one of the three following methods : variation of resistance, plotting of resonance curve, and the use of a dynatron. If the resistance of the same circuit is measured successively by each of these methods, one is surprised to find that the results may differ by 50%. These discrepancies arise from two causes : (1) the adoption of different conventional definitions of the resistance of an oscillating circuit, whereas it is possible to define an immutable intrinsic resistance ; and (2) the modifications, in frequency and in losses, inherent in each arrangement of circuits. In the following work the relations are found between apparent and intrinsic resistances, and a circuit arrangement is described which embodies all three methods and gives constant results." The intrinsic resistance is the sum, covering the whole circuit, of the quotients of the power dissipated in an element of the circuit by the square of the effective value of the current in that element. The resistance thus defined is given by the resonance-curve method and the dynatron method. In the resistance-variation method, on the other hand, the ratio taken is that of the total power spent to the current intensity at the point where the additional resistance is inserted—the middle or the ends of the coil being particularly convenient (Frühauf, 1931 Abstracts, p. 509). An apparent resistance is thus obtained which is smaller or larger than the intrinsic resistance, according to the case. The comparison of the three methods necessitates a correction, which is the more important the larger the inductance of the coil and the smaller the terminal capacity. Each of the elements of an oscillating circuit is the seat of losses due to Joule effect, to dielectric hysteresis, and to dielectric leakage. To render the results of the three methods comparable, the frequency and the losses must remain the same ; the components must preserve the same relative positions ; the dynatron must remain always connected to the condenser terminals, and the generator must remain tuned to the circuit during the various measurements on one particular frequency. Table II shows the results obtained with a circuit arrangement specially designed, and with the corrections arrived at. It is concluded that the resonance-curve method is liable to serious errors, besides being lengthy ; the dynatron method (using either the setting-in or breaking-off of oscillation—*see* Table III for a comparison of these two procedures) is very practical, though it requires very exact measurement of frequencies and inductances ; the valve should be chosen with as small a value of negative resistance ρ_m as possible, for the discrepancies between the results with this method and with the resistance-variation method decrease as $L/CR - \rho_m$ decreases. It is regrettable that this dynatron method is not always applicable. The resistance-variation method is capable of giving a good degree of accuracy and is applicable in all cases, but requires a somewhat complicated equipment.

The Measurement of Impedance : Discussion.—Astbury : Starr. (*Journ. I.E.E.*, July, 1934, Vol. 75, No. 451, p. 62.) Discussion on a point in Astbury's paper referred to in July Abstracts, p. 392.

Über die Anwendung der Iterationsmethode zur angenäherten Berechnung der Wirbelströme und des Wirkwiderstandes (The Application of the Iterations Method [applied to Vector Potentials] to the Approximate Calculation of Eddy Currents and Dissipative Resistance).—Heymann. (*Archiv f. Elektrot.*, 7th June, 1934, Vol. 28, No. 6, pp. 331–340.)

The method is applied to single, double, and three-phase conductors ; then to the single-layer solenoid, the toroidal coil, the lead-covered cable, the cylindrical and ring-shaped multi-layer coils, and the Krarup cable ; and finally to a conductor of arbitrary shape in a homogeneous field.

A High [and Ultra-High] Frequency Electrodynamic Ammeter [for Frequencies above 20 Mc/s : Closed Ring freely suspended in Field of Exciter Coil : Period of Torsional Vibration gives Value of Current].—H. M. Turner and P. C. Michel. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 680–681: short summary only.)

Grundsätzliches über die Messung von Verlustwinkeln und die Bedeutung der Temperaturabhangigkeit des $\tan \delta$ in der Hochfrequenztechnik (Fundamental Principles in the Measurement of Dielectric Phase Angles, and the Importance of the Temperature-Variation of $\tan \delta$ in High-Frequency Technique [Errors in Usual Methods when applied to New Low-Loss Insulators : Thermal Breakdown of Transmitting Valves and Condensers, particularly in Short-Wave Working]).—E. Müller and O. Zinke. (*Hochf:tech u. Elek:akus.*, May, 1934, Vol. 43, No. 5, pp. 145–149.)

Referring to recent papers giving the loss angles of the new ceramic materials in the wavelength range of 300–6 metres (*see* for example Rohde and Schlegelmilch, 1933 Abstracts, pp. 512–513), the writers remark that the errors arising in such measurements, where $\tan \delta$ is of the order of 10^{-4}, are not mentioned. Part I of the present paper therefore examines the errors to which the resonance method of measurement is liable. In this method a generating circuit is coupled to a resonant circuit including a condenser C (with the dielectric to be tested) which is later replaced by a loss-free condenser C_2 with a series resistance R_c. The current I_2 measured in the resonant circuit (Rohde replaced this measurement by that of the voltage across the fixed coupling inductance) is used as an indication of the total resistance : the writers show that an error of 1% in its measurement may cause a 36% error in $\tan \delta$ when this amounts to 1×10^{-4}, and a 3.6% error when it amounts to 10×10^{-4}. This is for a test circuit with a decrement of 1%, the wavelength being 100 m and the capacity 150 $\mu\mu$F. The way to reduce this error is to keep the decrement below 1% by constructing the test-circuit coils and connections of large-diameter copper tube or of copper strip. Another source of error is the stray capacity C_P parallel to the true dielectric capacity C_{12} of the test condenser. Instead of $\tan \delta$ being equal simply to $R_c \omega C_{12}$, it is equal to this multiplied by $(1 + C_P/C_{12})^2$ and if $C_P = 0.1 C_{12}$ the neglect of this correction factor will lead to an error of 21%.

For transmitting purposes it is desirable that the losses of the new insulators should be measured, at least within a few per cent., at different temperatures between 20° and 300°C. The construction of transmitting condensers and the life of transmitting valves are related very closely to the temperature variation of $\tan \delta$ for the insulating materials employed. Part II elaborates this point : " the amount of heat $N_A \tan \delta$ developed by a reactive power N_B increases markedly with the temperature T. But at any temperature T only a definite amount of thermal energy N_A can be dissipated in a stationary manner. A stable final temperature thus sets in at the point of intersection of the curves $N_B \tan \delta$ and N_A. If the two curves do not intersect, a thermal breakdown takes place."

Verlustwinkelmessung bei 10^8 Hz (Dielectric Loss Measurement at 10^8 Cycles/Second [including Data on the New Insulating Materials for Ultra-High Frequencies]).—L. Rohde and H. Schwarz. (*Hochf:tech. u. Elek:akus.*, May, 1934, Vol. 43, No. 5, pp. 156–158.)

After mentioning the defects of the calorimetric and Lecher wire methods of loss measurement, when applied to low-loss materials at frequencies above 5×10^7 c/s, the writers describe an equipment which gives rapid measurements on solid dielectrics at frequencies up to 10^8 c/s, " with an accuracy sufficient for all practical purposes." The principle of the method is that the resistance increase of an oscillatory circuit, due to the introduction of the dielectric into the air-gap of its condenser, is measured.

Of the two ways in which this resistance-increase can be measured, the damping-measurement method (otherwise so useful) becomes troublesome when the damping is very low and the frequency very high, since very small wavelength- or capacity-changes have to be measured. This is troublesome at wavelengths between 2 and 7 metres, where the absolute value of the oscillator capacity is very small and the production of a known change in the 4th decimal place is therefore extraordinarily difficult. On the other hand, the otherwise very suitable substitution method has the difficulty, at these ultra-short wavelengths, that a standard resistance which is free from skin effect is unobtainable. It is, however, possible to calculate the skin effect of the wire and to check it for different cross sections. The differences, as found in practice, lie within 3%, so that within these limits the absolute value may be relied on. In the substitution method one generally starts with a known resistance R_n as close as possible to the resistance R_v to be measured, and then calculates the exact value from potential measurements (if R_n cannot be made exactly equal to R_v) namely of V_1 (without the dielectric), V_2 (with the dielectric) and V_3 (without dielectric but with R_n introduced). This procedure requires very loose coupling and a constant or negligible loading by the potential-measuring instrument. Fig. 1 shows a valve voltmeter being used for this purpose. Both conditions are hard to fulfil with ultra-short waves : a powerful oscillator is needed, especially when the losses are large, while when they are small it is difficult to get sufficiently different values for V_1 and V_3. By the use of a compensating voltage E_0 a portion of the voltages V_1, V_2, V_3 acting on the valve voltmeter can be cancelled, so that only the differences need to read on the galvanometer G. A great increase of sensitivity results, allowing the smallest losses met with in practice to be measured. The coupling between oscillator and test circuit is so adjusted that a full-scale deflection of G occurs for the low-loss air condenser ; various values of R_n are then introduced and a curve drawn showing the connection between the reading of G and these values, for a particular wavelength and a particular capacity. A family of these curves, for different capacities, enables the relation for any capacity to be interpolated. With such a calibration, the deflection decrease produced on introducing the dielectric test piece gives a direct measurement of the resistance R_v (not R_n as printed). By this method, measurements can be made below the smallest reference resistance available : thus if this smallest resistance (say 0.1 ohm) produces a deflection decrease of 20 scale divisions, the resistance corresponding to one scale division can be taken with sufficient accuracy as 0.005 ohm. This substitution method is applicable to loss angles up to about 50×10^{-4}. Above this value the damping-measurement method becomes suitable, but the initial damping is most simply measured by a substitution method.

The special precautions taken in the design of the oscillator and the test circuit, to render them satisfactory at frequencies up to 10^8 c/s, are described. For the former, the symmetrical two-valve circuit shown in Fig. 1 was found particularly satisfactory, on account of its short connections and its good phase conditions. At 10^8 c/s it was possible to keep a heterodyne note constant within ± 100 c/s for 10 minutes when the valves were heated by an accumulator and the anode voltage was taken from the mains off a " stabilisator." In the test circuit the clamping plates of the condenser had a diameter of 30 mm, the dielectric test pieces being 35 mm in diameter and from 1 to 4 mm thick (according to their dielectric constants) so that the resulting capacities were about 10 to 16 cms. The reference resistances were of constantan wire, and were provided with a miniature plug-and-socket board giving four values, from 0.05 to 0.4 ohm nominal value : the actual r.f. value was taken for each measurement from the skin-effect calibration curves. The table of results applies to dry test pieces : the effect of moisture was found to be quite small at 3 m. In addition to the well-known materials (including the new kinds such as Condensa C) the table gives the values for rock-salt, sylvine and fluorspar, " since it is interesting in searching for the causes of loss to examine substances whose molecular construction is thoroughly known " (*cf.* Goldhammner, under " Subsidiary Apparatus and Materials").

CONDENSER ANALYSER [for testing Paper, Mica, and Oil Dielectric Condensers, using Glow-Tube Indicator to measure Leakage Current].—(*Electronics*, June, 1934, p. 197.)

ON THE MODE OF ACTION OF EXTERNALLY-CONTROLLED [" Schaltgesteuerter "] RECTIFIERS FOR MEASURING PURPOSES.—Pfannenmüller. (*See* under " Subsidiary Apparatus and Materials " : also below.)

ÜBERBLICK ÜBER DIE MESSVERFAHREN MIT GLEICHRICHTERN (Survey of Measuring Processes using Rectifiers [Barrier-Layer, Vibrating Contact, and Valve]).—H. Pfannenmüller. (*Archiv f. Elektrot.*, 7th June, 1934, Vol. 28, No. 6, pp. 356–384.)

" In recent years measuring methods with rectifiers have found a wider employment chiefly owing to the development of the barrier-layer and vibrating-contact rectifiers. The present work gives a survey of the field. Methods described in other papers will be dealt with briefly, or only referred to, whereas the ' separately controlled ' rectifier [' separately excited,' ' switch-controlled ' rectifier, ' synchronous switch or commutator '], and some recent applications, will be considered more fully." The separately-excited barrier-layer rectifier enables much smaller voltages to be measured, since the control voltage has no longer to be taken from the test circuit. Particular attention is paid to the " vector meter " (*see* preceding reference) and its application to the measurement of a.c. resistances ; dielectric losses in condensers, cables and insulators ; as a null instrument for bridge circuits ; in current-transformer testing ; testing earthing connections (avoiding the interference due to stray currents in the neighbourhood of the earthing points) ; and for the measurement and control of resistances in electrolytic furnaces. Other applications of the separately-controlled rectifier as a " vector meter," particularly for high frequencies up to 10 kc/s, are in the control of commercial processes (such as in the manufacture of rubber, paper, and textiles), the measurement of permeability in the making of Krarup cable, and other similar " ultra-micrometric " uses (*see* various past abstracts under " Miscellaneous "). Other uses, as a quotient meter, include the measurement of power factor, ohmic and reactive resistances, temperature, and modulation (Hallen) ; while the last sections deal with the measurement of sums and differences of the absolute values of two voltages ; the measurement of apparent power, wave form, and peak values ; frequency analysis ; the removal of the error-causing action of the self-inductance of the measuring instrument ; and finally, the use of barrier-layer valves as resistances varying with load, for the stabilisation of voltage. Nearly 100 literature references are included.

A SCREEN-GRID VOLTMETER WITHOUT EXTERNAL LEAK [Independent of Frequency from Low Audio to Ultra-High Frequencies : Linear Calibration between 0.1 and 10 Volts : Application as Detector for Broadcast and Ultra-Short Waves, Lecher Wire Resonance Indicator, etc.].—R. King. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, pp. 771–780.)

FIELD-INTENSITY METER FOR ULTRA-SHORT WAVES.—King. (*See* paper referred to above.)

METHOD OF MEASURING PEAK VOLTAGES OR CURRENTS, BASED ON THE PROPERTIES OF THYRATRONS.—G. Marchal. (*Rev. Gén. de l'Élec.*, 30th June, 1934, Vol. 35, No. 26, pp. 205–206D : summary only.)

CONSIDERATIONS IN THE USE OF THE ELECTROSTATIC PEAK VOLTMETER [Conditions for Correct Operation : the Unsuitability of the Metal Rectifier : etc.].—E. H. W. Banner. (*Journ. Scient. Instr.*, July, 1934, Vol. 11, No. 7, pp. 218–223.)

MESSUNG DER ZÜNDSPANNUNG VON MIT WECHSELSTROM BETRIEBENEN ENTLADUNGSRÖHREN (Measurement of the Ignition Potential of Discharge Tubes driven off Alternating Current [Simple and Accurate Method using Telephone as Indicator]).—R. Rompe and H. Schmellenmeier. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, pp. 265–267.)

Some Thermal Methods of measuring Power Loss in Vacuum Tubes [Best is Thermopile with Filter removing Heat coming from Glass and leaving that from Plate].—F. P. Cowan. (*Proc. Inst. Rad. Eng.*, June, 1934, Vol. 22, No. 6, p. 681: short summary only.)

A New Signal Generator [and Associated Equipment] for Receiver Testing.—Kammerloher. (*See* under "Reception.")

A Bridge Method for determining the Coupling Coefficient of an Air-Cored Transformer.—L. M. Chatterjee. (*Zeitschr. f. Physik*, 1934, Vol. 89, No. 9/10, pp. 601–604.)

The purpose of this paper is to show that Heydweiller's modification of the Carey Foster bridge (Carey Foster, *Proc. Phys. Soc. Lond.*, 1887, Vol. 8, p.137; Heydweiller, *Ann. der Physik*, 1894, Vol. 53, p. 499) gives, by suitable arrangement, a direct measurement of the coupling coefficient of an air-cored transformer.

Comprehensive Theory of a Power Factor Bridge.—J. C. Balsbaugh and A. Herzenberg. (*Journ. Franklin Inst.*, July, 1934, Vol. 218, No. 1, pp. 49–97.)

The bridge described is of the Schering type, with symmetrical measuring arms, a variable condenser in one of the high-voltage arms, and variable condensers for balancing the capacitance between the bridge arms and shield. It is most frequently used for calculations of the dielectric constant of oil samples, with very high voltage gradients, but the general theory is worked out in great detail and methods of checking the measurements are described.

Insulation Test Set giving an Audible Alarm [using a Neon Tube and Gas-Filled Relay].—(*P.O. Elec. Eng. Journ.*, July, 1934, Vol. 27, Part 2, p. 135.)

The Observation of Reflecting Galvanometer Deflections [Increased Sharpness of Image and Reduction of Fatigue by use of Green Filter].—R. V. Jones. (*Journ. Scient. Instr.*, July, 1934, Vol. 11, No. 7, pp. 233.)

Mesures de Rayonnement (Field-Strength Measurements [and the Work of the Laboratoire National de Radioélectricité]).—P. David. (*L'Onde Élec.*, April, 1934, Vol. 13, No. 148, pp. 172–188.) A paper read before the Societé des Radioélectriciens, in November, 1933.

The Perfection of Quartz and Other Crystals and Its Relation to Surface Treatment.—R. M. Bozorth and F. E. Haworth. (*Phys. Review*, 1st June, 1934, Series 2, Vol. 45, No. 11, pp. 821–826.) The full paper, a summary of which was referred to in August Abstracts, p. 449, r-h column.

Quartz-Crystal-Controlled Oscillator Circuits [and a New Circuit reducing Energy Dissipation in Crystal and consequent Frequency Drift].—Meahl. (*See* under "Transmission.")

The Frequency Stabilisation of Valve Oscillators by the use of Screen-Grid Valves.—Schweimer and Pungs. (*See* under "Transmission.")

Primary Frequency Standard has Accuracy of 99.9999% [Description of Crystal-Controlled Equipment at Constant Frequency Monitoring Station, Grand Island, Nebraska].—J. G. Beard. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, pp. 15–17.)

An Absolute Determination of the Ampere.—H. L. Curtis and R. W. Curtis. (*Bur. of Stds. Journ. of Res.*, June, 1934, Vol. 12, No. 6, pp. 665–734.)

SUBSIDIARY APPARATUS AND MATERIALS

Physical Investigations on the New Magnetic Materials [Isoperms: the Cause of Their Very Small Remanence].—M. Kersten. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, pp. 249–257.)

The preparation and properties of the isoperms have already been described (*cf.* Dahl and Pfaffenberger, Abstracts, June, p. 335, l-h column: *see* also 1933, p. 637, r-h column): the predominant characteristic is the remarkably small remanence, amounting to a few hundredths of the saturation induction, whereas ordinary materials have a value about half that of saturation. The merits of isoperms as magnetic materials have been shown to depend chiefly on this small remanence, so that an explanation of the cause of this is of importance: it is with this problem that the present paper deals. The remanence dealt with is not the absolute value I_R but the ratio $r = I_R/I_S$.

The only material of comparable qualities is the compressed powder core material composed of magnetic powder mixed with electrically and magnetically insulating substances. The writer begins, therefore, with an examination of the magnetisation curves of such compressed powders, Fig. 1 giving a comparison between powdered cores without, and with, the admixture of insulating substances. The curves of ring stampings, without and with demagnetising gaps, present exactly the same appearance. "The reduction of remanence, for the production of an adequate stability, is arrived at in compressed powder material simply by the admixture of the insulating substances, which do not seriously alter the 'true' magnetic properties of the powder particles." A short account of Becker's theoretical work shows that in general the remanence depends only (apart from the saturation, which for a given temperature is a constant of the material) on the distribution of direction of the "preferred positions" of the elementary bodies, or particularly on the distribution of the natural tensions (due to the treatment of the material) where these are of predominant influence on the preferred positions. "An extremely small remanence ratio $r = I_R/I_S$, without the use of a gap, is only possible (according to equation 1a) when the preferred positions of practically all the elementary bodies are approximately transverse to the field direction ($\delta \approx \pi/2$—*see* Fig. 2). This condition is fulfilled, for example, when a soft nickel wire is subjected to a strong longitudinal pull in the direction of the field." In this case the preferred positions are transverse to the pull, and the remanence in the direction of the tension amounts only to a small percentage of the saturation. But such an effect cannot be produced by the natural tensions resulting from the working of the material. There is, however, a way in which, without the use of elastic tensions, such transverse preferred directions can be obtained. In the hexagonal single crystals of cobalt the main axis forms a strongly marked magnetic preferred direction on the grounds of crystallographic symmetry, practically independent of the presence or absence of natural tensions, and such a crystal displays a very small remanence when magnetised transversely to this axis. Unfortunately for this explanation, all the important magnetic materials crystallise cubically.

The true solution, it is concluded, is that the abnormally small remanence shown by the cold-rolled isoperms is due to actions taking place during rolling, favoured by the high temperatures developed at the individual slip planes. These actions result in the formation, from the cubic crystals, of a non-cubical fibrous or layered texture which leads to a magnetic preferred position perpendicular to the plane of the rollers.

THE RECORDING CAPABILITIES AND SENSITIVITY OF THE CATHODE-RAY TUBE WITH DOUBLE [Two-Stage] CONCENTRATION.—F. Malsch. (*Archiv f. Elektrot.*, 7th June, 1934, Vol. 28, No. 6, pp. 349–355.)

Author's summary :—" It is shown to what degree a double [two-stage] concentration can be applied to improve the performance (spot brightness, absolute and relative recording speed, and sensitivity) of a cathode-ray tube. For tubes with very active small electron-sources [cold-cathode tubes] a magnification of the image is useful : both lenses are in the neighbourhood of the stop [at the first image]. For tubes with relatively large electron sources of small current density [hot-cathode tubes] a marked reducing effect by the pre-concentrating lens is necessary, with a stopping-out of the outer rays." For a previous treatment of double concentration as a means of increasing sensitivity *see* Brüche and Scherzer, February Abstracts, p. 100 : " they do not, however, mention that with an increase of the angle β the spacing between the plates of the deflecting system must also be increased."

A NEW SENSITIVE METHOD FOR THE OSCILLOGRAPHIC RECORDING OF PERIODIC HIGH-FREQUENCY OSCILLATIONS [Joubert Disc Principle applied to High Frequencies].—C. Nebel. (*Physik. Ber.*, 15th June, 1934, Vol. 15, No. 12, pp. 969–970.)

From the Siemens laboratories : " A simple and sensitive process is described, which is developed on the principle of the Joubert disc (point-by-point recording of a.c. processes) so as to be applicable to high frequencies, and which—by means of a distortionless transformation of the h.f. curve to low frequencies—allows the processes to be recorded on a simple loop oscillograph. A series of possible circuits with instruments or valves is first described, all capable of giving a point-by-point curve record by a short-time excitation from a narrow voltage peak. Of these circuits particular attention is then given to those by which it is possible to establish a linear relation between the voltage peak and the voltage to be recorded. A simple way of getting the voltage peak is to arrange that a current, of as rectangular wave form as possible and of the same frequency as the curve under measurement, excites a very strongly damped train of a high harmonic (*e.g.* the tenth), the first half wave of which is used as the voltage peak. . . ."

TIME/CURRENT BLOWING CHARACTERISTICS OF INSTRUMENT FUSES STUDIED BY SPECIAL CATHODE-RAY OSCILLOGRAPH EQUIPMENT [with " Machine-Gun " Electron Delivery, Non-Recurring Sweep Circuit, and Recording by Ordinary Camera].—E. V. Sundt : Littelfuse Company. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, pp. 20–21.)

A SIMPLE METHOD OF MEASURING THE INDUCTANCE AND CAPACITY OF TRANSFORMERS AND COILS BY MEANS OF THE CATHODE-RAY OSCILLOGRAPH.—Nowotny. (*See* under " Measurements and Standards.")

MAGNETICALLY SELF-FOCUSING STREAMS [of High-Velocity Electrons : Theoretical Investigation].—W. H. Bennett. (*Phys. Review*, 15th June, 1934, Series 2, Vol. 45, No. 12, pp. 890–897.)

THE CATHODE-RAY TUBE AS A PROBLEM OF GEOMETRICAL ELECTRON-OPTICS.—Brüche. (*See* under " Phototelegraphy and Television.")

SENSITIVITY OF PHOTOGRAPHIC FILMS TO X-RAYS AT LOW TEMPERATURES.—G. E. M. Jauncey and H. W. Richardson. (*Journ. Opt. Soc. Am.*, May, 1934, Vol. 24, No. 5, pp. 125–126.)

THE THEORY OF THE IONISATION MANOMETER.—N. Morgulis. (*Physik. Zeitschr. der Sowietunion*, No. 3, Vol. 5, 1934, pp. 407–417 : in German.)

A NEW VACUUM METER, PARTICULARLY FOR LARGE MERCURY-VAPOUR RECTIFIERS [giving Continuous Indication or Control : based on Pressure Dependence of Electron Current].—W. Dällenbach. (*E.T.Z.*, 3rd May, 1934, Vol. 55, No. 18, pp. 440–441.)

A MINIMUM-WATER-FLOW RELAY FOR THE PROTECTION OF WATER-COOLED APPARATUS.—H. Beck. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 15, 1934, pp. 221-223.)

A PORTABLE LOOP OSCILLOGRAPH FOR SIMULTANEOUS OBSERVATION AND RECORDING [by means of Rotating Polygonal Mirror].—W. S. Kasansky. (*E.T.Z.*, 7th June, 1934, Vol. 55, No. 23, pp. 564–565 : summary only.) *Cf.* Oplinger, May Abstracts, p. 280, l-h column.

THE IGNITRON.—D. D. Knowles and E. G. Bangratz. (*E.T.Z.*, 7th June, 1934, Vol. 55, No. 23, pp. 563–564 : summary only.) *See* also Ludwig, Maxfield and Toepfer, June Abstracts, p. 336, r-h column.

THE CURRENT DIRECTOR [" Stromrichter "], A NEW FIELD OF ELECTROTECHNICS [including Distinctions between " Gleichrichter," " Wechselrichter," and " Umrichter," etc.].—H. Kreissel. (*Funktech. Monatshefte*, May, 1934, No. 5, pp. 177–182.)

STEEL RECTIFIER TUBES: A HIGH-VOLTAGE GRID-CONTROLLED TUBE CAPABLE OF DELIVERING ONE MILLION WATTS.—Allis-Chalmers and Brown-Boveri Companies. (*Rad. Engineering*, May, 1934, Vol. 14, No. 5, p. 16.)

CONSIDERATIONS AND EXPERIMENTAL RESEARCHES ON ARC RECTIFIERS USING GAS AT ATMOSPHERIC PRESSURES.—C. di Pieri. (*L'Elettrotec.*, 25th May, 1934, Vol. 21, No. 15, pp. 332–339.)

PHYSICAL AND TECHNICAL PROBLEMS OF THE ELECTRIC ARC.—R. Seeliger. (*Ibid.*, 5th June, 1934, Vol. 21, No. 16, pp. 350–357.)

ON THE MODE OF ACTION OF EXTERNALLY-CONTROLLED [" Schaltgesteuerter "] RECTIFIERS FOR MEASURING PURPOSES.—H. Pfannenmüller. (*Physik. Ber.*, 15th June, 1934, Vol. 15, No. 12, p. 969.)

From the Siemens laboratories. Used in this way, rectifiers are not controlled by the current to be rectified but by auxiliary currents and potentials. Rectification is represented as a product, in which the rectifiers appear as periodically varying resistances or conductances in the form of Fourier series. The procedure is illustrated by application to the " vector meter " (for l.f. current and voltages), to copper-oxide rectifiers, and to rectifiers with special conductance and resistance curves, for eliminating harmonics. *See* also below.

SURVEY OF MEASURING PROCESSES USING RECTIFIERS.—Pfannenmüller. (*See* under " Measurements and Standards.")

CONTACT RECTIFIERS [Crystal Detectors: Contact Rectifiers: Construction, Properties, and Application of Copper-Oxide Rectifiers: Cold Discharge and Theory].—S. Kaneko and C. Nemoto. (*Circulars Elektrot. Lab. Tokyo*, No. 97, 1933, 68 pp.)

INSULATING LIQUIDS IMPROVE CONTACT TO COPPER OXIDE [Resistance-Reducing Effect of Finely Divided Carbon (between Soft Metal Electrode and Copper Oxide) reproduced by Mineral Oils, particularly Kerosene: Large Effect of Iodine dissolved in Kerosene, critically Dependent on Voltage].—L. F. Slezak. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, p. 20.)

PAPERS ON THE MEASUREMENT OF THE DIELECTRIC LOSS, ETC., OF INSULATING MATERIALS AT HIGH AND ULTRA-HIGH FREQUENCIES.—Müller and Zinke: Rohde and Schwarz. (*See* under " Measurements and Standards.")

NEW INSULATING MATERIALS, PARTICULARLY FOR HIGH-FREQUENCY TECHNIQUE [" Freqwahn," a new " Hard Paper " Compound Insulator, and Its Use in Condensers, H.F. Stranded Wires, etc.].—W. Ruppert. (*E.T.Z.*, 21st June, 1934, Vol. 55, No. 25, pp. 608–610.)

ON A NEW DIELECTRIC MATERIAL FOR POWER CONDENSERS [Paper impregnated with Castor-Oil/Bakelite Compound].—H. Wada. (*Journ. I.E.E. Japan*, April, 1934, Vol. 54 [No. 4], No. 549, pp. 268–272: English summary pp. 36–37.)

ELECTRICAL INSULATING MATERIALS [Survey, including the New Materials—Plexigum, Neoresit, Sinterkorund, Sipa, Kerafar, etc.].—R. Vieweg. (*E.T.Z.*, 14th June, 1934, Vol. 55, No. 24, pp. 573–576: Discussion, *ibid.*, 5th July, No. 27, p. 683.)

" KUNSTHARZPRESSTOFFE " (Moulding Materials with Artificial Resin Base [Book Review]).—W. Mehdorn. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, p. 288.)

THE SURFACE RESISTIVITY OF ADSORBED MOISTURE FILMS ON GLAZED PORCELAIN [Application to Insulators].—F. W. Johnson. (*Phil. Mag.*, July, 1934, Series 7, Vol. 18, No. 117, pp. 63–80.)

THE BEHAVIOUR OF CERAMIC INSULATORS UNDER TEST WITH SURGES [and the Detection of Partial Breakdown in Opaque Insulators by Schering Bridge Measurements].—W. Furkert. (*Zeitschr. V.D.I.*, 7th July, 1934, Vol. 78, No. 27, p. 828.)

THE MATHEMATICAL TREATMENT OF THE ELECTROSTATIC FIELD IN INSULATORS.—W. Wessel. (*Physik. Ber.*, 1st June, 1934, Vol. 15, No. 11, p. 877.)

EXPERIMENTAL INVESTIGATION OF INITIAL CURRENTS IN DIELECTRICS. I. ROCK-SALT: II. GLASS [Measurements from 5 and 4×10^{-4} Second after Application of Voltage].—A. D. Goldhammer and N. A. Salessky. (*Physik. Zeitschr. der Sowietunion*, No. 4, Vol. 5, 1934, pp. 523–544 and 545–552: in German.)

ON THE ELECTRICAL INITIAL CONDUCTIVITY AND THE " TRUE " CONDUCTIVITY IN ROCK-SALT CRYSTALS.—A. D. Goldhammer. (*Ibid.*, pp. 553–561.) *See* also Rohde and Schwarz, under " Measurements and Standards."

A RÉSUMÉ OF RECENT WORK ON THE ANOMALOUS BEHAVIOUR OF DIELECTRIC LIQUIDS.—W. Jackson. (*Journ. I.E.E.*, July, 1934, Vol. 75, No. 451, pp. 93–110.)

CONTRIBUTION TO THE PROBLEM OF THE INSULATING OF HIGH-TENSION MACHINES.—W. Eberspächer and H. Stach. (*Physik. Ber.*, 1st June, 1934, Vol. 15, No. 11, p. 887.)

SUPERHETERODYNE TUNING CONDENSER DESIGN —FOR USE IN MULTI-RANGE RECEIVERS [Mathematical Solution for Curve of Condenser Plates: Application to Two-Band Receivers].—H. Schwartzmann and L. G. Burnell. (*Electronics*, June, 1934, pp. 180–182.)

REMARK ON OUR PAPER " ON THE DIELECTRIC OF ELECTROLYTIC CONDENSERS."—Jauch and others: Günterschulze. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, p. 285.) *See* June Abstracts, p. 334, for the paper in question.

DRY ELECTROLYTIC CONDENSERS [with Curves: a New Design with Aluminium Wire Tabs: Cellophane as Separator: etc.].—R. J. Covert. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, pp. 18–19.)

SIMPLE APPROXIMATE FORMULAE FOR THE SELF-CAPACITY OF MULTI-LAYER COILS.—Zuhrt. (*See* under "Measurements and Standards.")

PROTECTING CHOKE COILS WITH SMALL INTERNAL CAPACITY [for Protection against Surges: Capacity of Main Winding reduced by connecting in series with Low-Capacity Air-Insulated Turns: with Oscillograms].—H. Trage: Förster. (*E.T.Z.*, 14th June, 1934, Vol. 55, No. 24, pp. 582–583.)

VARIABLE INDUCTANCE FOR SHORT-WAVE CIRCUITS [Four Sides of Square adjustable to Very Oblique Rhomboid by Threaded Diagonal].—J. B. Roch and L. Peyson. (French Pat. 747 762: *Funktech. Monatshefte*, June, 1934, No. 6, pp. 250–251.)

"NETWORK SYNTHESIS" [Book Review].—C. M. Gewertz. (*Science Progress*, July, 1934, Vol. 29, No. 113, p. 159.)

"The treatment is almost entirely mathematical. With the help of complex matrices and determinants an astonishing degree of success has been attained in the synthesis of networks presenting no small difficulty . . ."

THE GENERATION OF HIGH D.C. POTENTIALS [by H.T. Transformer and a Series of Hot-Cathode or Rotating Point-and-Plate Rectifiers distributed at Different Points of the Winding].—H. Boekels. (*E.T.Z.*, 21st June, 1934, Vol. 55, No. 25, pp. 603–604.)

A REGENERATIVE NULL INDICATOR [Reinartz Circuit as Recording Potentiometer (registering 1 Millivolt or less) increased in Sensitivity by addition of Regeneration].—D. E. Noble: Reinartz. (*Electronics*, June, 1934, p. 190.)

STATIONS, DESIGN AND OPERATION

THE 17-CENTIMETRE MICRO-WAVE LINK BETWEEN LYMPNE AND ST. INGLEVERT.—A. Clavier. (*L'Onde Élec.*, March, 1934, Vol. 13, No. 147, pp. 101–125.)

For previous papers on this service *see* June Abstracts, p. 338. The present paper includes a mathematical treatment of the generation of the oscillations. Section 7 deals with the "curves of constant frequency," giving the relation between the potentials which must be applied to the "oscillatory" (positive) electrode and to the "reflecting" (retarding) electrode, in order to obtain the maximum power at the "optimum" frequency for one particular adjustment of the aerial system. Section 8 points out the importance of these curves in practice: thus by choosing a part of the curve where the output varies linearly and the relation between the potentials is also linear, and applying the modulating potential in the proportion indicated by the curve, the valve will remain on the same frequency and an amplitude modulation of the order of 40% can be obtained.

DIRECTIONAL BROADCASTING [as at WFLA].—Wilmotte. (*See* under "Aerials and Aerial Systems.")

SHARED CHANNEL BROADCASTING.—Aiken. (*See* under "Reception.")

THE BEATING OF CABLE-CONTROLLED COMMON-WAVE STATIONS ON THE LORENZ COMPANY'S SYSTEM.—Arendt. (*See* abstract under "Transmission.")

BROADCASTING IN INDIA: EXPERIMENTS IN SHORT-WAVE TRANSMISSION.—(*Electrician*, 22nd June, 1934, Vol. 112, No. 25, p. 863.)

IMPROVING THE BROADCAST OF RECORDED PROGRAMMES.—Miller. (*See* under "Acoustics and Audio-frequencies.")

BROADCAST DISTRIBUTION.—Noel Ashbridge. (*Wireless World*, 6th and 13th July, 1934. Vol. 34, pp. 2–5 and 24–26.)

The Chief Engineer of the B.B.C. deals with the B.B.C.'s policy of transmitter distribution, and outlines future policy.

BROADCASTING UNDER HITLER.—"Wandering Wave." (*Wireless World*, 13th July, 1934, Vol. 34, pp. 22–23.) An account of the political significance of broadcasting in Germany at the present time.

BANDIT TRACKING FROM THE AIR.—(*Wireless World*, 20th July, 1934, Vol. 34, pp. 42–43.)

An account of experiments carried out with wireless-equipped aeroplanes and cars by the Marconi Company in conjunction with the Leicestershire police.

MAINS BROADCASTING [Editorial on Withdrawal of Clause in Electricity (Supply) Bill].—(*Electrician*, 8th June, 1934, Vol. 112, No. 23, p. 781.) *See* July Abstracts, p. 396, r-h column.

THE ERICSSON CENTRALISED RADIO SYSTEM.—S. Friberg. (*Ericsson Review*, No. 2, 1934, pp. 89–92.)

THE PRINCIPLE AND APPLICATION OF A DIAGNOSTIC ANALYSIS OF THE MEASURED FIELD STRENGTHS OF A STATION [in Mountainous Country].—Devik. (*See* under "Propagation of Waves.")

DEVELOPMENT AND RESULTS OF THE GERMAN MARINE OBSERVATORY TIME-SIGNAL SERVICE.—A. Repsold and H. C. Freiesleben. (*Physik. Ber.*, 15th June, 1934, Vol. 15, No. 12, p. 920.)

TERMINAL EQUIPMENTS [for Radio-Telephone Circuits: General Considerations, and the Marconi R.C. 49 Equipments].—(*Marconi Review*, May/June, 1934, No. 48, pp. 20–29: to be continued.)

GENERAL PHYSICAL ARTICLES

POTENTIAL MEASUREMENTS IN FILAMENT ELECTRON BEAMS [Discontinuity of Potential at Surface of Beam].—W. Rollwagen. (*Zeitschr. f. Physik*, 1934, Vol. 89, No. 7/8, pp. 395–411.)

The Frequency and Width of Moving Striae in the Positive Columns of the Rare Gases.—W. Pupp. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, pp. 257–262.)

The Electrical Breakdown of Air at Very High Frequencies [340 m—20 m Wavelengths: at Atmospheric and Reduced Pressures].—F. Müller. (*Archiv f. Elektrot.*, 7th June, 1934, Vol. 28, No. 6, pp. 341–348.)

Accommodation Coefficient and the Fraction of Current carried by Ions in a Low-Voltage Arc.—I. A. Getting. (*Phys. Review*, 1st June, 1934, Series 2, Vol. 45, No. 11, pp. 788–793.)

The Question of the Anomalous Electrical Conductivity of Thin Metals [Optical Method of Conductivity Measurements confirms existence of Anomalies: These therefore are Not due to Bad Contacts between Molecules].—H. Murmann. (*Zeitschr. f. Physik*, 1934, Vol. 89, No. 7/8, pp. 426–430.)

The Spontaneous Variation of Optical Transparency of Thin Metal Films. Connection with the Spontaneous Resistance Variation and the Structure of the Films [Dispersion Equations Applied to Film Phenomena].—A. Jagersberger. (*Zeitschr. f. Physik*, 1934, Vol. 89, No. 9/10, pp. 564–581.)

Influence of the Anharmonic Part of the Thermal Oscillations of Atoms on the Electrical Resistance of Metals.—A. Smirnov. (*Physik. Zeitschr. der Sowietunion*, No. 4, Vol. 5, 1934, pp. 599–606: in English.)

Dipole Molecules.—E. Rabinowitsch. (*Naturwiss.*, 13th July, 1934, Vol. 22, No. 28, pp. 477–479.)

A short account of a discussion held by the Faraday Society at Oxford in April; among the subjects referred to was the effect of a solvent in producing a "dispersion curve" of the dielectric constant. The absorption effect can be more easily measured (by the increase of temperature) than the variation of the dielectric constant.

MISCELLANEOUS

A General Analytical Representation of a Class of Closed Linear Figures in One Plane [Experimental Results approximated by Fourier Series].—G. Grobe. (*Zeitschr. f. Physik*, 1934, Vol. 89, No. 5/6, pp. 388–394.)

Note on the Graphical Solution of Problems in Transmission [avoiding Use of Hyperbolic Functions of Complex Angles].—T. B. Vinycomb. (*P.O. Elec. Eng. Journ.*, July, 1934, Vol. 27, Part 2, pp. 136–138.)

"Rechnung mit Operatoren nach Oliver Heaviside" (Calculation with the Heaviside Operational Calculus [Letter prompted by Book Review]).—B. van der Pol: Berg. (*Hochf:tech. u. Elek:akus.*, June, 1934, Vol. 43, No. 6, pp. 210–211.)

"Funktionentafeln mit Formeln und Kurven" (Tables of Functions with Formulae and Curves [2nd Revised Edition: Book Review]).—E. Jahnke and F. Emde. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 15, 1934, p. 285.)

"Higher Mathematics for Engineers and Physicists" [Book Review].—I. S. and E. S. Sokolnikoff. (*Rad. Engineering*, June, 1934, Vol. 14, No. 6, p. 14.)

The Determination of a Parabolic Formula to Represent a Series of Observations.—J. H. Awbery. (*Proc. Phys. Soc.*, 1st July, 1934, Vol. 46, Part 4, pp. 574–582.)

Graphic Statistics [and the Graphical Representation of Frequency Distribution].—A. F. Dufton: Bliss. (*Science*, 22nd June, 1934, Vol. 79, No. 2060, pp. 564–565.)

Radio Research ("Report of the Radio Research Board for the Period 1st January, 1932, to 30th September, 1933" [Book Review]).—(*Electrician*, 15th June, 1934, Vol. 112, No. 24, p. 819: *Engineering*, 15th June, 1934, Vol. 137, pp. 680–681.)

"National Physical Laboratory: Report for the Year 1933" [Book Review].—(*Journ. Scient. Instr.*, July, 1934, Vol. 11, No. 7, pp. 234–235.)

The Activities of the Physikalisch-Technische Reichsanstalt in 1933.—S. Erk. (*Zeitschr. V.D.I.*, 30th June, 1934, Vol. 78, No. 26, pp. 796–799.) Based on the full report published in the *Physik. Zeitschr.*, No. 6, Vol. 35, 1934.

"Theory of Radio Communication. Post Office Engineering Department, Technical Instructions" [Book Review].—(*Electrician*, 15th June, 1934, Vol. 112, No. 24, p. 823.)

"Year Book of the Research Institute of the AEG" [Book Review].—AEG. (*E.T.Z.*, 21st June, 1934, Vol. 55, No. 25, p. 619.)

The Progress in Radio Technique and Radio Communications during 1933.—(*Rev. Gén. de l'Élec.*, 30th June, 1934, Vol. 35, No. 26, pp. 888–890: summary only.)

Some Ideas on the Administration of Scientific Societies.—E. Delcambre. (*L'Onde Élec.*, April, 1934, Vol. 13, No. 148, pp. 193–196.)

Some Aspects of Patent Protection.—J. W. Williamson. (*Journ. Scient. Instr.*, July, 1934, Vol. 11, No. 7, pp. 205–209.)

Carrier-Current Telegraphy with "Band Receivers" [as used for the 4-Channel Service across the Straits of Korea on a 120 Sea-Miles Single-Cored Cable].—T. Kajii and S. Matsumae. (*E.N.T.*, June, 1934, Vol. 11, No. 6, pp. 195–201.)

The "band receiver" is an arrangement combining the functions of a filter with those of an amplifier and a rectifier. The anode circuit of a triode (Fig. 1) includes a system composed of resonant and anti-resonant circuits, whose shunt and series elements contain induction coils. The secondary windings of the latter are so connected in series with the input transformer that the e.m.f. induced in the shunt element attenuates the input voltage, while that induced in the series element improves it. The circuit possesses great amplifying power and good selectivity; with a suitable grid bias it also rectifies. The good selectivity results from the combined action of the two retroaction-coupling coils, when the phase relations of the induced voltages are correct in the secondary of the input transformer. For multiple telegraphy with a large number of channels, therefore, the Type II band receiver (Fig. 5) with phase adjusting circuit is preferable, the constructionally simpler Type I being reserved for a system with few channels (*cf.* transmission band curves of the two types, Figs. 7 and 8, for a middle frequency of 2 300 c/s).

For the highly attenuating single-cored submarine cable of the Korea Straits service lower frequencies were needed, and 300 and 500 c/s were chosen for one direction and 700 and 900 c/s for the other. A speed of 60–80 Bauds was obtained. The speed was the higher, the higher the carrier frequency, not only because the attenuation and impedance characteristics of a submarine cable are more distorted at low frequencies but also because of the smaller number of periods included in a signal. On the 300 c/s channel, therefore, a push-pull connection was used for the band receiver.

The principle is applicable to high frequencies as well as to note frequencies, and is suitable for carrier-current working, superposed voice-frequency telegraphy, and for ringing connections in loaded long-distance telephone cables.

SECTION PROTECTION OF H.T. SYSTEMS BY GUIDED HIGH-FREQUENCY CONTROL.—H. Neugebauer. (*Physik. Ber.*, 1st June, 1934, Vol. 15, No. 11, pp. 888–889.)

A PROPELLER-VIBRATION INDICATOR [Electromagnetic Device for mounting on End of Engine Shaft: applicable to other Torsional Vibrations].—H. L. Dryden and L. B. Tuckerman. (*Bur. of Stds. Journ. of Res.*, May, 1934, Vol. 12, No. 5, pp. 537–542.)

ON THE ELECTRICAL METHOD OF MEASURING SMALL VIBRATIONS, AND ITS APPLICATION TO THE MEASUREMENT OF VIBRATIONS OF AIRSCREW BLADES [Capacity Ultra-Micrometer Method].—Obata, Morita and Yoshida. (*Physik. Ber.*, 1st June, 1934, Vol. 15, No. 11, pp. 843–844.)

ELECTRONIC AIDS TO VOICE CULTURE.—(*Electronics*, June, 1934, p. 186.)

WHY ELECTRONIC-MADE SANDPAPER CUTS BETTER [Abrasive Particles oriented and arranged by Electrostatic Field].—(*Ibid.*, p. 187.)

RADIO IS LATEST AID TO "PAINLESS" DENTISTRY (Drill Vibrations counteracted by "Rhythmic Vibrations" of Earphone clamped to Forehead or Mastoid-Bone).—E. Drosen. (*Sci. News Letter*, 16th June, 1934, Vol. 25, No. 688, p. 377.)

SOME POSSIBILITIES IN ELECTRONIC EXHIBITS.—McDill. (*Electronics*, April, 1934, p. 119.)

THE MACHINE DESIGNER LOOKS AT ELECTRONIC INDUSTRIAL CONTROL [New Requirements for Valves, etc., in Industrial Control Devices].—R. W. Carson. (*Electronics*, May, 1934, pp. 156, 170.)

ULTRA-MICROMETRIC DEVICES [for Industrial Control Purposes] USING RECTIFIERS.—Pfannenmüller. (*See* abstract under "Measurements and Standards.")

GALVANOMETER AMPLIFICATION BY PHOTOCELL.—V. R. Jones: Hill. (*Nature*, 9th June, 1934, Vol. 133, p. 872.)

A note on Hill's letter (July Abstracts, p. 398, r-h column) on the use of a Weston "photronic" cell in a differential galvanometer relay. The present writer has obtained ten times the amplification obtained by Hill, as described in a note referred to in *Journ. Scient. Instr.*, March, 1934.

MAIL SORTING ROOM DAYLIGHT INTENSITY CONTROLLED BY PHOTOCELLS.—(*Electronics*, June, 1934, p. 186.)

TRAIN LIGHT CONTROLLED BY PHOTOCELLS [Belgian Railway].—(*Ibid.*, p. 186.)

LIGHTHOUSES AND BEACONS OPERATED BY PHOTOCELLS.—(*Ibid.*, p. 186.)

LUSTRE OF TEXTILES COMPARED BY PHOTOCELLS.—(*Ibid.*, p. 187.)

PRECISE LIGHT MEASUREMENT [Vacuum-Tube Voltmeter-Photometer with Balanced Photocell Input].—D. G. Fink. (*Electronics*, June, 1934, pp. 190–191.)

AN ULTRA-VIOLET PHOTOELECTRIC SPECTROPHOTOMETER.—D. H. Follett. (*Proc. Phys. Soc.*, 1st July, 1934, Vol. 46, Part 4, No. 255, pp. 499–507: Discussion pp. 507–509.)

ON THE PHYSIOLOGICAL EFFECTS OF THE ULTRA-SHORT WAVE.—S. Sasada. (*Journ. I.E.E. Japan*, April, 1934, Vol. 54 [No. 4], No. 549, p. 297: letter, in Japanese.)

A NEW APPARATUS FOR ULTRA-SHORT-WAVE THERAPY [the "Ultrapandoros," giving 100–400 Watts at 3.25—7 and 15 metres].—J. Pätzold. (*Physik. Ber.*, 1st June, 1934, Vol. 15, No. 11, p. 891.) A Siemens-Reiniger equipment.

FARADIC CURRENTS SUPERPOSED ON "INFRA-LONG" WAVES, FOR MEDICAL PURPOSES.—Saxl. (*See* abstract under "Transmission")

LOCATING NEW DEPOSITS IN MINES BY RADIO OBSERVATIONS [Field Strength Measurements on Broadcasting and other Stations].—Fritsch. (*See* abstract under "Propagation of Waves.")

TELEPHONY BY ELASTIC WAVES IN WATER [Submarine Telephony between Ships, etc., by Modulated Supersonic Waves generated by Piezoelectric Method].—M. Marro. (*L'Onde Élec.*, April, 1934, Vol. 13, No. 148, pp. 189–192.) For a previous reference *see* March Abstracts, p. 167, l-h column. With 25 w at the transmitter speech has been received up to about 5 miles.

Some Recent Patents

The following abstracts are prepared, with the permission of the controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

SHORT-WAVE MODULATORS

Convention date (Germany), 6th December, 1932.
No. 407652

The transmission line feeding short-wave energy to a dipole aerial is coupled to the latter through a diaphragm, which is mechanically vibrated by the sound or picture frequencies to be radiated. The variable coupling modulates the outgoing carrier. To maintain the load on the generator constant, a "Phantom" aerial is provided, with a variable coupling 180 deg. out of phase with that of the main aerial.

Patent issued to J. Pintsch, Akt.

HIGH-FREQUENCY GENERATORS

Convention date (France), 3rd August, 1932.
No. 407602

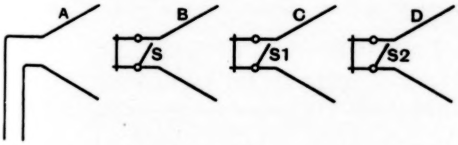
High-frequency oscillations, suitable for use in diathermy, are generated by a spark-gap and condenser circuit, the actual gap between the electrodes being filled by a phenol-condensation product, or a resin, containing a mixture of fine metallic particles, such as copper filings. This produces a "grape-shot" effect, splitting-up the main discharge into a series of minute spark-gaps. This increases the frequency of the output.

Patent issued to M. L. Y. de Paniagua.

DIRECTIONAL AERIALS

Convention date (U.S.A.), 1st September, 1932.
No. 407881

Comprises means for rapidly reversing the direction of radiation from a "Beam" aerial system of the type in which the antenna wires are arranged at an angle to each other, the radiated energy being concentrated along the line bisecting the angle. An energised aerial of this kind is shown at A and is "backed" by one or more similar but unenergised or "floating" aerials B, C, D. The direction of radiation either lies along the line B, C, D, if these aerials act as "boosters," or in the opposite direction if they act as reflectors. The action of the aerials B, C, D depends upon the relative phases of the currents induced in them by radiation from the main aerial A, and this in turn depends upon their tuning. According to the invention, the tuning is changed so as to reverse the direction of the beam by means of switches S, S_1, S_2 which are controlled from a remote point and are arranged to short-circuit a quarter-wavelength section of the wires.



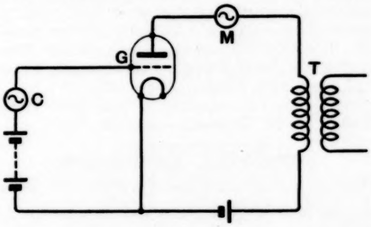
No. 407881.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

MODULATING SYSTEMS

Application date 19th September, 1932.
No. 407934

Sideband frequencies are produced in the absence of a carrier wave by passing a modulating current through an impedance, such as a valve, the value of which is varied cyclically at carrier frequency.



No. 407934.

For instance, a positive potential is applied to the grid G in series with a source C of carrier frequency. Under these circumstances the total space current flowing depends almost wholly upon the grid potential, although the proportion of this space current which reaches the plate is a function of the plate voltage. A modulating voltage is applied to the plate from a source M, and sideband frequencies are drawn off from the transformer T for further amplification. The action depends upon the fact that the plate is operated at a voltage which does not determine the total discharge current, whilst at the same time the internal "slope" resistance of the valve varies cyclically with the voltage applied to the grid.

Patent issued to F. B. Dehn.

TELEVISION SYSTEMS

Convention date (Germany), 7th March, 1932.
No. 407823

The "line" and "picture" synchronising frequencies, instead of being transmitted at different amplitudes, are sent at equal amplitudes, and the necessary adjustment is effected at the receiving end by varying the spacing, and therefore the sensitivity, of the control electrodes in the cathode ray tube.

Patent issued to M. von Ardenne.

"STATIC" ELIMINATORS

Convention date (*U.S.A.*), *10th August*, 1932.
No. 407872

Relates to arrangements in which the aerial is located some distance away from the set, in order to avoid local inductive interference, and is coupled to it through a screened "transmission line" or down-lead. The invention resides in the use of a compact case or "unit," designed to be suspended from the aerial and containing an impedance-matching transformer for coupling the aerial to the line feeding the set.

Patent issued to Amy, Aceves and King, Inc.

DIRECTION-FINDING SYSTEMS

Application date, *5th October*, 1932. *No.* 408015

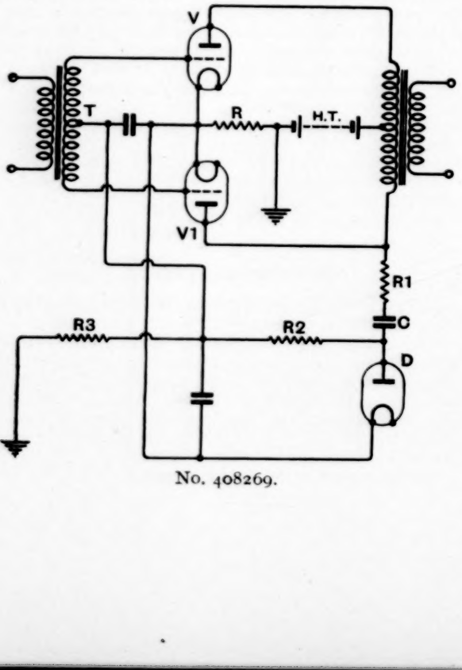
A series of say six transmitting beacons are linked by land-line to a central control station from which synchronised signals are sent to each in turn in a definite sequence. At the receiving end, the incoming signals are made to control a rotating disc in such a way that, when the receiving frame is pointing at a particular beacon, the name or characteristic call sign of that station is thrown in visible form on a disc or screen. The object is to provide a simple direction-finding system which can be operated by a navigating officer having no knowledge of the Morse code.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.; H. M. Dowsett; and R. Cadzow.

PUSH-PULL AMPLIFIERS

Application date, *4th October*, 1932. *No.* 408269

The two valves *V*, *V*1 are fed in push-pull from the transformer *T*. An auxiliary rectifier *D*, connected to the output circuit, is arranged so that as the input voltage increases, the rectifier automatically throws the grid bias more negative. In effect the valves *V*, *V*1 function as a class *A* amplifier until the input voltage exceeds a certain value, whereupon the diode *D* comes into operation to convert the system into a class *B* amplifier. Normally the grids are biassed to the middle point of the characteristic curve by a resistance *R* in the anode-cathode circuit of the amplifier. The anode of the rectifier *D* is fed from the output of the main amplifier through a resistance *R*1 and condenser *C*, whilst its cathode is earthed through the resistance *R*. The resistances *R*2, *R*3 form a potentiometer shunt across the diode rectifier *D*, from which an intermediate tapping is taken to the grids of the amplifiers.



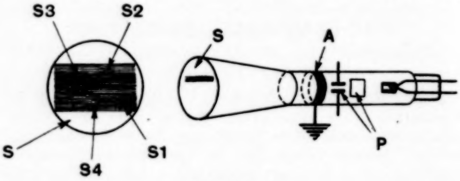
No. 408269.

Patent issued to Electric and Musical Industries Ltd. and A. H. Cooper.

CATHODE-RAY TUBES

Convention date (*Germany*), *10th August*, 1931.
No. 408297

In high-powered cathode ray tubes, a type of distortion known as "fringing" is liable to occur. It takes the form of irregular spots indicated at *S*1, *S*2, *S*3, *S*4 in Fig. 1A, and is caused by undulatory movements of the ray at right-angles to its normal path across the fluorescent screen *S*. The disturbance is attributed to the effect of free ions which are formed between the deflecting electrodes and the end screen, and which are set into vibration by oscillatory fields from the electrodes or from some external source. According to the invention, the free ions which are the source of the trouble are "neutralised" by the action of an additional electrode *A* interposed between the deflecting plates *P* and the screen. The electrode preferably consists of two annular plates or metallic coatings, mounted on the inside or outside of the glass wall, and earthed.



No. 408297.

Patent issued to K. Schlesinger.

THERMIONIC CATHODES

Application dates, *6th December*, 1932 *and* 10*th March*, 1933. *No.* 408062

The inventors have discovered by X-ray analysis that the most efficient composition for an oxide-coated cathode is approximately two molecules of barium oxide to three molecules of strontium oxide. Also that when the efficiency of the coating is reduced by "flashing," the barium evaporates leaving a richer content of strontium. The same explanation is advanced as the reason for "poisoning," one of the main causes of failure on life test when the vacuum is relatively imperfect. According to the invention an improved cathode is made with an inner layer relatively rich in barium, and an outer layer relatively poor in barium.

Patent issued to M. Benjamin and H. P. Rooksby.

PERMEABILITY TUNING

Application date, 5th October, 1932. No. 408271

Powdered-iron cores are mounted on a single screw-threaded shaft, in close proximity to the local-oscillator and preselector coils in a superheterodyne set, and are moved simultaneously in or out of the coils to vary the tuning. The core of the local-oscillator coil is differently shaped from that of the H.F. input, so as to maintain the constant difference necessary to produce the beat frequency. The tuning coils for the medium- and long-wave ranges are both wound concentrically on a single core, and are tuned (after the wave-band switch has been operated) by the same movable core.

Patent issued to E. J. Wyborn; A. W. Martin, and E. K. Cole, Ltd.

DIRECTION-FINDING

Convention date (U.S.A.), 27th November, 1931.
No. 408211

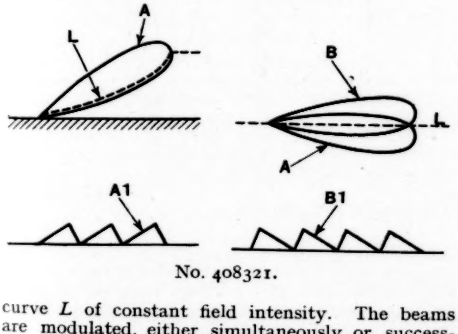
A local current is generated by rotating a coil in the earth's magnetic field, and its phase is compared with that of the incoming signal from a distant Beacon station. Both currents are preferably produced by a single radiogoniometer coil, which is rotated at constant speed in the pick-up field from two crossed frame aerials. The current produced by earth-field induction is filtered out from that due to the received signals, and the phase-difference is determined by a phase-meter. When used for aerial navigation, the phase-meter is initially set to give zero deflection when the craft is on its correct course. Any subsequent deviation is then automatically indicated.

Patent issued to Electrical Research Products Inc.

AIRCRAFT WIRELESS

Convention date (Germany), 6th January, 1932.
No. 408321

Two short-wave beams A, B are radiated at an angle to each other and to the horizontal, the overlapping parts of the field forming a landing curve L of constant field intensity. The beams are modulated, either simultaneously or successively, with signals of the form shown at A_1, B_1, so that a zero-set indicating meter at the receiver only shows a deflection if the craft deviates from the correct landing track. Alternatively the indicator may be arranged so that it is illuminated only so long as the pilot holds to the proper line of descent.



No. 408321.

Patent issued to C. Lorenz Akt.

WIRED WIRELESS

Application date, 7th October, 1932. No. 408320

Relates to a method of utilising a telephone trunk line for carrying a broadcast programme at high fidelity, simultaneously with other signals. The programme is transmitted on a carrier-suppressed single side-band, located well above the frequency range of the other signals, and a "pilot" frequency is sent in the intermediate zone so provided. The unwanted side-band is eliminated by filter circuits comprising a piezo-electric crystal in series or parallel with a pure resistance circuit. For instance, the frequency range from zero to 3 k.c. is used for ordinary telephony; the range from 3 to 30 k.c. is allotted to a number of carrier telephony or telegraphic channels; whilst the single side-band broadcast programme extends from 35 to 43 k.c., with a pilot frequency of 34 k.c. The pilot frequency is used to control the oscillator which reintroduces the suppressed carrier-wave at the receiving end.

Patent issued to Standard Telephones and Cables Ltd.; K. G. Hodgson; B. B. Jacobsen, and F. Ralph.

TUNING DIALS

Application date, 5th October, 1932. No. 408576

In order to allow a single large dial to be used for both medium- and long-wave stations, both scales are of the same radius, and a series of movable "blanking strips" are used to render only one of the scales visible at a given time. For the medium-waves, for instance, the radial strips are arranged to disclose the right set of markings, whilst on the long-wave setting, the strips are shifted to one side so as to hide the medium-wave markings and disclose the long-wave scale.

Patent issued to E. J. Wyborn; A. W. Martin and E. K. Cole, Ltd.

TELEVISION SYSTEMS

Convention date (U.S.A.), 26th September, 1931.
No. 408656

It is important in practice to arrange that the "background" brilliancy of the reproduced picture should vary in accordance with the overall light intensity of the scene being transmitted. According to the invention this adjustment is effected automatically—instead of by manual control—by first rectifying a part of the incoming signal energy and then using the rectified voltage to vary the initial bias applied to the grid of the cathode-ray tube receiver. As the amplitude of the received signals increases in the positive sense, the background brilliancy of the fluorescent screen is automatically heightened, whilst a falling-off in signal amplitude produces a reverse effect on the screen.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

TONE COMPENSATION

Application date, 16th November, 1932. No. 408727

Relates to means for compensating for high-note loss irrespective of the amount of reaction in circuit. A differential condenser is used in the output circuit of a back-coupled detector valve, and is short-circuited when receiving signals from the local station so that the reaction coil is out of action. For distant stations the differential condenser passes a certain amount of feed-back energy, and at the same time places the coupling-condenser in shunt across the input coil of the next amplifier. As the high-note loss is thus made to vary with the degree of reaction the arrangement allows a constant amount of note compensation to be applied to the L.F. amplifier stage for all settings of the reaction control.

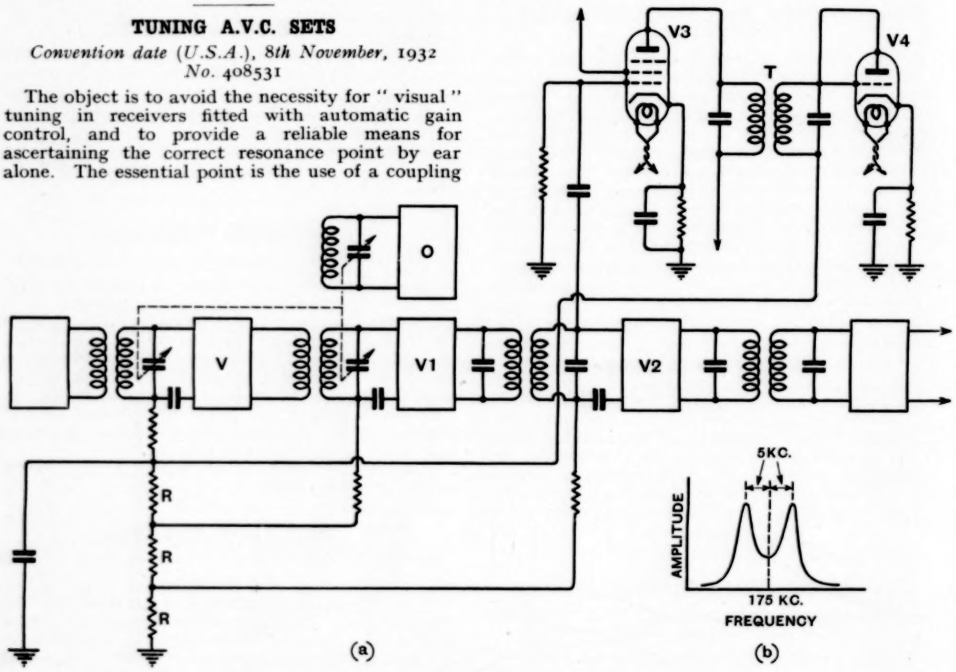
Patent issued to G. V. Dowding and Marconi's Wireless Telegraph Co., Ltd.

TUNING A.V.C. SETS

Convention date (*U.S.A.*), *8th November,* 1932
No. 408531

The object is to avoid the necessity for "visual" tuning in receivers fitted with automatic gain control, and to provide a reliable means for ascertaining the correct resonance point by ear alone. The essential point is the use of a coupling element which has a double-humped curve, so that any movement of the tuning control to one side or other of the proper setting produces a definite decrease of the volume of sound. As shown in the Figure, a superhet receiver comprises a high-frequency valve *V*, local oscillator *O*, first detector *V*1, and intermediate-frequency amplifier *V*2. A part of the I.F. energy is diverted from the valve *V*2 to an auxiliary amplifier *V*3, and is rectified by a diode *V*4. A potential-divider *R* in the output circuit of the diode supplies gain-control bias to the grids of the amplifiers *V*, *V*1, *V*2. The coupling transformer *T* between the A.V.C. amplifier *V*3 and the diode *V*4 has a double-humped curve as shown in Fig. 1B, so that it passes more energy on either side of the true resonance point.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.



No. 408531.

WIRELESS "ROAD" SIGNALS

Convention date (*Germany*), *14th November,* 1932.
No. 408547

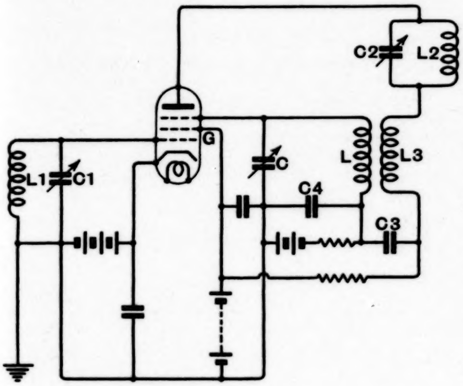
To enable the driver of one car to signal his intention of "overtaking" another, the first car is fitted with a small spark transmitter which projects a short-range "beam" of waves on to a coherer fitted at the back of the second car. The rectified impulses from the coherer actuate a local relay which lights up a warning lamp on the dash-board. Alternatively it may ring a bell or work a buzzer arranged near the head of the driver. The arrangement provides an unmistakable indication of the intention to overtake, in a manner which cannot be ignored by the driver ahead.

Patent issued to H. Gossler.

PENTODE SUPERHETS

Convention date (U.S.A.), 14th January, 1933.
No. 408903

A pentode valve is used as a combined oscillator and first detector in a superhet receiver. The local oscillation circuit L, C is decoupled from the signal input circuit $L1$, $C1$ by the intermediate grid G. The anode circuit $L2$, $C2$ is tuned to the intermediate frequency, and is coupled through the coil $L3$ and condensers $C3$, $C4$ to the local oscillation circuit. This "mixed" coupling is arranged to maintain a constant transfer of energy over the whole of the tuning range. In addition the condenser $C3$ serves to align the tuning of the ganged circuits. The third grid has no appreciable influence on the emission from the cathode, this being entirely controlled by the voltages on the first and second grid.



No. 408903.

Patent issued to Hazeltine Corporation.

VALVE CATHODES

Convention date (Germany), 11th September, 1931.
No. 408657

A previously oxidised tungsten wire is first introduced into position inside the anode of the valve, and is then sprayed with a stream of evaporated metal, so that a thin layer of the activating substance is deposited over its centre surface. The arrangement allows a completely uniform coating to be applied to the cathode in an economical manner.

Patent issued to S. Loewe and B. Wienecke.

LOUD-SPEAKER FITTING

Application date, 18th October, 1932. No. 408965

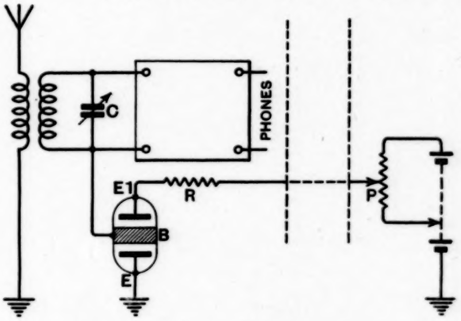
A simple and ready means for connecting-up a second loud speaker, particularly in the case of cabinet sets where provision is not usually made for this purpose, consists of an adaptor unit, which is interposed between the power-valve and the valve socket. The adaptor automatically inserts a coupling condenser in the anode circuit of the power valve, and is provided with terminals from which the leads for the extra loud speaker are taken.

Patent issued to Kolster-Brandes, Ltd.; and T. D. Ward Miller.

AN "ELECTRONIC" CONDENSER

Convention date (U.S.A.), 16th October, 1931.
No. 408943

An electron discharge tube is made to serve as a variable condenser by using an external plate or band to control the volume of the glow discharge between two internal electrodes. One application is described in connection with a method of phase-modulation. Or, as shown in the figure, the device can be utilised for controlling the tuning of a distant wireless set. The usual tuning-condenser C of the set is connected to the external band B of the discharge tube, one of the internal electrodes E being earthed, whilst the other is connected through a resistance R to a variable tapping on a distant potentiometer P. The latter is used to vary the voltage across the tube. This changes its effective shunt capacity to earth and so controls the tuning of the receiver. Advantages of the "condenser" tube are that it has no moving parts, is simple to construct, and is reliable in action.



No. 408943.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

LIGHT-SENSITIVE CIRCUITS

Application date, 12th December, 1932. No. 409068

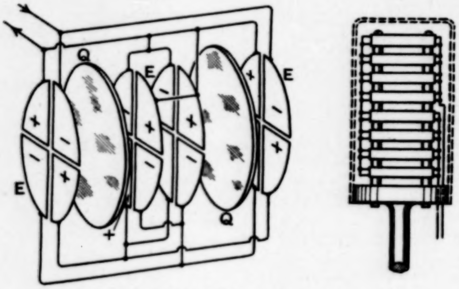
In order to run a light-sensitive amplifier direct from A.C. mains, the light-sensitive cell is coupled to the grid of the valve and is shunted by a resistance and high-capacity condenser arranged in parallel. This serves to smooth the rectified current impulses produced by the valve from the A.C. supply. An additional series resistance is used to maintain a constant potential on the grid, until this is distributed by the effect of the light to be measured falling on the sensitive cell. A relay of the direct-current type is then operated by the amplified anode current.

Patent issued to H. W. Pook and Radiovisor Parent, Ltd.

PIEZO-ELECTRIC APPLIANCES

Application date, 1st November, 1932. No. 409040

Microphones and loud-speakers are built up from a series of discs cut from Rochelle salt or a similar piezo-electric crystal. The Figure shows a loud-speaker diaphragm comprising crystal discs *Q* with interposed quadrant electrodes *E* which may be connected in parallel as shown, or in series or series-parallel. An arrangement of piezo-electric "sound cells" suitable for a microphone is also illustrated.



No. 409040.

Patent issued to A. H. Stevens.

VOLUME AND SELECTIVITY CONTROL

Convention date (U.S.A.), 29th September, 1932. No. 409193

Automatic volume control is combined with means for regulating the selectivity, or fidelity response, as between distant and local stations. The output from the detector valve *V* is passed through a galvanometer *G* which rotates a shaft *D* against the return action of a spring *S*. The shaft carries one plate of a condenser *C* in series with the aerial circuit, together with vanes *V*1, *V*2 which "spade tune" the intervalve coupling circuits. For maximum range and selectivity, the capacity element *C* and vanes *V*1, *V*2 are thrown away from their associated circuit components. As the knob *X* is turned to bring in a local station the output current from the detector valve *V* rotates the shaft *D* to increase the capacity *C*, which, by a Wheatstone Bridge effect, reduces the aerial coupling to the first valve. Simultaneously the vanes *V*1, *V*2 broaden the tuning of the coupling circuits, so as to cover the full side-band width for optimum quality.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

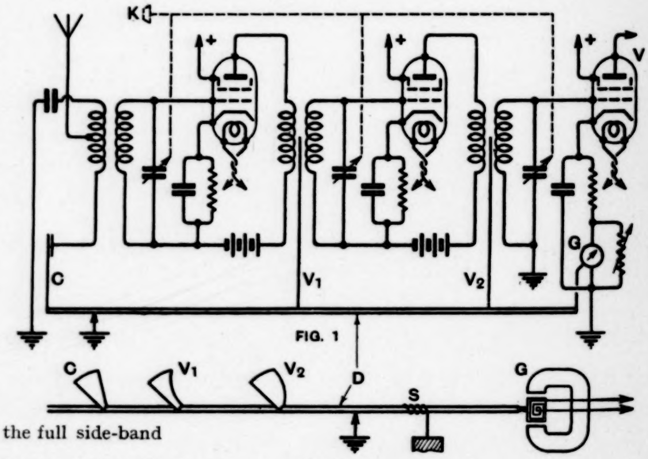


FIG. 1

FIG. 2

No. 409193.

A.C. VALVES

Convention date (Germany), 20th August, 1932. No. 409183

The cause of "humming" in mains-driven valves is attributed (*a*) to partial oxidation or atomisation of the filament, which gives rise to continual variations in resistance and temperature; (*b*) to bodily displacement of the filament inside its insulating tube; (*c*) to the leakage of current from the filament (particularly in the case of A.C. valves) to the cathode layer, due to insulation weakness at the high temperatures. According to the invention these defects are overcome in manufacture by first inserting the heating filament into the insulating tube, next filling the latter with an insulating powder containing aluminium oxide, and finally baking and de-gassing the whole. Contact between the insulating powder and the cathode is reduced by providing the latter with longitudinal or transverse ribs, or by fitting insulating rings or distance-pieces between the two.

Patent issued to Radio-Akt. D. S. Loewe.

MICROPHONES

Convention date (U.S.A.), 12th April, 1932. No. 409368

In a moving-coil microphone, the coil is attached to a diaphragm and is suspended in the air-gap between tapered pole-pieces. In the centre pole-piece, below the diaphragm, is an air chamber provided with "damping" openings. These openings are initially over-dimensioned but are afterwards suitably restricted, to give the required frequency response, by closing them in with porous material, such as a fabric disc. The chamber thus forms an acoustic network or "impedance" which controls the vibration characteristics of the diaphragm.

Patent issued to Electrical Research Products Inc.